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Effects of Temperature, Humidity, and Larval Weight on the Duration of Prepupal and Pupal Stages of the Pale Western Cutworm, *Agrotis orthogonia* Morr. (Lepidoptera: Noctuidae)[1]

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The pale western cutworm, *Agrotis orthogonia* Morr., a pest of crops in the plains areas, occurs in central Alberta and Saskatchewan in Canada southward to various areas of Oklahoma, Texas, and New Mexico in the United States. It has been suggested that in the prepupal stage this cutworm is able to adapt itself to a wide range of climatic and geographic conditions and to retain a univoltine life cycle. The investigations reported here were made to determine the effects of temperature, moisture, and larval weights on the duration of the prepupal and pupal stages.

Methods

The experiments were conducted at 20°, 25°, and 30° C. in temperature rooms where the daily variation was less than one degree. At each of these temperatures, saturation deficits of 3.2, 11.9, and 15.8 mm. of mercury were obtained with mixtures of sulphuric acid and distilled water in closed glass jars (Wilson, 1921).

Eggs laid in the laboratory by females collected in the field were incubated at room temperature for approximately 15 days and then stored at 0° C. Later, as required, larvae were hatched from these eggs and fed sprouts of Thatcher wheat. Approximately 150 larvae were hatched and reared at each temperature until the moths emerged. They were bulk-reared in groups of 25 to the third moult and then singly to the prepupal stage by methods described by Jacobson and Blakeley (1957). When each individual reached the prepupal stage, it was placed head uppermost in a cell made from a 40-mm. length of 10-mm.-bore glass tubing with the ends closed with copper screen. The cells containing the prepupae reared at any one temperature were assigned at random to the three levels of humidity at the same temperature. Pupation and emergence occurred in these cells.

After the fifth moult the larvae were weighed daily until feeding ceased and until weight had decreased approximately 25 per cent. The duration of the prepupal period was recorded as the time from the date of maximum weight to the date of pupation. This was more precise than recording it from the date when feeding ceased or when the larvae assumed the shrunken, yellow-white colour. The pupae were weighed within 24 hours after moulting and the duration of the pupal period was recorded as the time from pupation to emergence.

Results

The duration of the prepupal stage varied directly, and the duration of the pupal stage inversely, with temperature (Table I). Analysis of variance showed that there were no significant differences in these durations at the various levels of humidity or between sexes.

[1]Contribution from the Entomology Section. From a thesis submitted by the senior author in partial fulfilment of the requirements for a M.Sc. degree, University of Alberta, 1954.

TABLE I
Mean durations (days) of the prepupal and pupal stages of *A. orthogonia* Morr.

Temperature (°C.)	Saturation deficit (mm. of mercury)					
	3.2		11.9		15.8	
	Prepupae	Pupae	Prepupae	Pupae	Prepupae	Pupae
20	12.0	27.5	13.0	28.0	12.5	27.0
25	21.0	29.5	18.5	25.5	20.0	27.0
30	33.0	24.5	32.0	25.0	30.5	24.5

The data from the three temperatures showed a relationship, which was independent of temperature, between weight of prepupae, weight of pupae, and durations of these stages. Regression coefficients showed that an average increase of 10 mg. of prepupal weight resulted in an average increase of .27 days in the duration of the prepupal stage. Similarly, each increase of 10 mgs. in the pupae was associated with an increase of .12 days in the duration of the pupal stage. At 25° C. the ranges and means of weights and durations of 48 individuals were as follows:—

	Weight (mg.)		Duration (days)	
	Range	Mean	Range	Mean
Prepupae	416–854	681	7–37	20
Pupae	220–479	368	21–46	27

Discussion

Crumb (1926) noted that single-brooded species of cutworms fitted their life cycle into a full year by prolonging the prepupal stage. Stanley (1936) found that high temperatures accelerated development of larvae and pupae but slowed prepupal development. Cook (1930) concluded that the prolongation at higher temperatures of the prepupal stage enabled the pale western cutworm to extend its range of occurrence southward and to adjust itself to local seasonal variations in climate. Experimental evidence herein (Table I) shows that the prepupal period is one of adjustment and can be referred to as a form of diapause as defined by Andrewartha (1952).

Weight of larvae is influenced by the kind and quantity of food consumed (McGinnis and Kasting, 1959) (Jacobson and Blakeley, 1958). Data herein have shown that durations of the prepupal periods are associated with weights of the prepupae. Similarly, Hocking (1953) found that larval nutrition affected the duration of the prepupal stage, as larvae fed on wheat seedlings had a shorter prepupal period than those fed on wheat leaves.

Summary

When prepupae and pupae of the pale western cutworm were reared at three levels of humidity at 20°, 25°, and 30° C., differences were found in the duration of these stages at the various temperatures but not between humidities.

There was no difference in the duration of the pupal stage between sexes. The duration of the pupal stage varied inversely, and the prepupal stage directly, with temperature. The longer prepupal stage at 30° C. was considered a form of diapause, which enables this cutworm to survive as a single-brooded species in the wide variation of climate from the prairies of Canada to Texas in the United States. An association was found between the weights of prepupae and the duration of these stages.

Acknowledgments

The assistance of Mr. C. Reimer, Statistical Research Services, Research Branch, Canada Department of Agriculture, Ottawa, Ontario, in suggesting various methods of statistical analyses is acknowledged.

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New Tropical Pyraustinae (Lepidoptera: Pyralidae)

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Glyphodes aurantivittalis, new species

Figs. 1, 8, 13

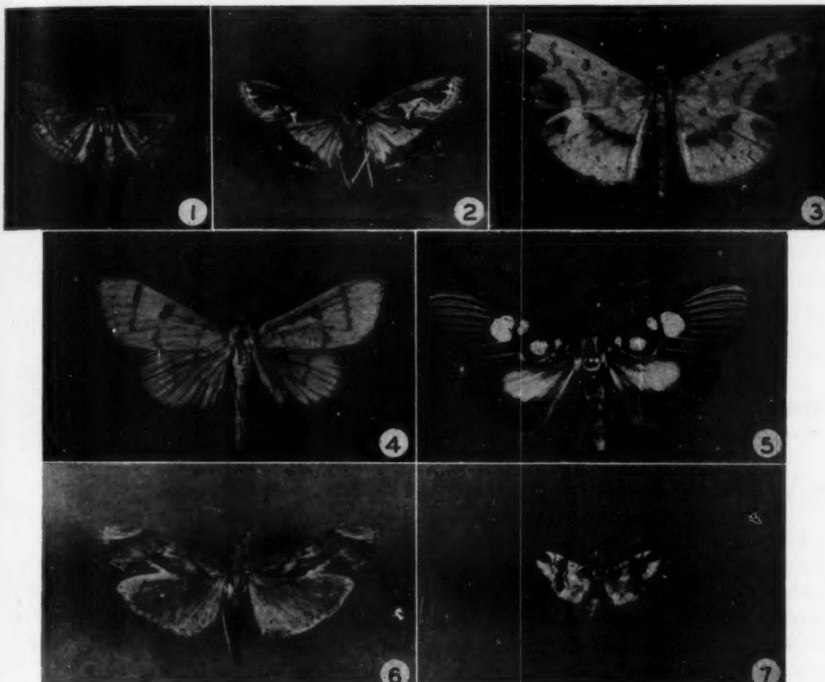
Wings, legs and antenna unmodified; frons flat and oblique, yellowish buff dorsally, fuscous on sides; labial palpus fuscous laterally with some orange scaling, yellowish buff dorsally, whitish buff at base beneath; maxillary palpus prominent, fuscous tipped with orange; proboscis orange-scaled at base; eye fuscous brown; antenna light brown; vertex rough-scaled, light yellowish brown; thorax above light yellowish brown; abdomen above light buff, with some yellowish scaling; body beneath whitish buff, darker posteriorly; legs yellowish buff above, whitish buff beneath. Forewing above translucent dull yellow; an oblique fuscous dash at base; an orange, inwardly and outwardly fuscous-bordered, outwardly oblique sub-basal band, beginning at R, indistinct in cell; an antemedial band, parallel to the sub-basal band, beginning at R, orange, bordered inwardly and outwardly with fuscous; a fuscous dot in anterior part of cell beyond antemedial line; an orange, inwardly and outwardly fuscous-bordered band on each side of discocellular, beginning at R, briefly fusing behind angle of cell, then diverging in an oval loop, converging to fuse with postmedial band near posterior margin; some specimens with an oval fuscous spot in the loop; postmedial band arising at R_4 well beyond cell; orange, bordered inwardly and outwardly with fuscous, broad and erect anteriorly, narrower and somewhat bowed outwards between M_2 and Cu_2, weakly retracted and broadened at junction with the two medial lines; subterminal line broad, orange, diffusely bordered inwardly and, except anterior to M_1, outwardly with fuscous, parallel to outer margin, a wedge-shaped excision of inner border in cell R_4; a prominent, blackish-fuscous terminal line; fringe yellowish brown, with a darker line in basal half. Hind wing above translucent dull yellow; an orange, fuscous-bordered discocellular bar; an orange, inwardly and outwardly fuscous-bordered postmedial band, beginning at R_s, retracted on Cu_2 nearly to angle of cell, then sinuous to anal margin; a broad subterminal band, parallel to margin, orange, diffusely bordered on both sides with fuscous; terminal line and fringe as on forewing. Wings beneath translucent dull yellow, markings of upper surface very weakly repeated on hind wing and basal half of forewing, somewhat more strongly repeated on distal half of forewing. Expanse 21 to 24 mm.

Male genitalia. Uncus long, slender at base, gradually dilated to a large, somewhat compressed, but only weakly setose, tip; tegumen moderately domed; vinculum narrow; valve broadly rounded, armed with a large, curved spine near sacculus; penis cylindrical, of normal length, armed with a fascicle of five long, needlelike cornuti.

Female genitalia. Ovipositor and posterior apophysis small; anterior apophysis longer but slender; ductus bursae long, slender and coiled, with a sclerotized collar shortly before ostium; bursa membranous.

Holotype, male, allotype, female, and six paratypes, Fort de Kock, Sumatra, E. Jacobson. Holotype, allotype and four paratypes in Leiden Museum; two paratypes type No. 6918, C.N.C.

This species somewhat resembles in general facies *Glyphodes* (*Tangla*) *zangisalis* (Walker), which I have seen from the same place, but it is easily



Figs. 1-7. 1, *Glyphodes aurantivittalis;* 2, *Diaphania antillia;* 3, *Botyodes borneensis;* 4, *Hedyleptopsis flava;* 5, *Typsanodes celebensis;* 6, *Agathodes transiens;* 7, *Syngamilyta nympha.*

distinguished from that species by the yellowish ground colour and different arrangement of the bands. The genitalia are quite different and the male antennae are unmodified in the new species.

Diaphania antillia, new species

Figs. 2, 9

Male antenna, wings and legs without special modifications; frons denuded in type, flattened and oblique; vertex between and behind antennae white, farther back dark brown; thorax light brown above, patagium tipped with white; abdomen above fuscous, with a creamy buff mid-dorsal stripe, broadened on third segment to form a trapezium containing a pair of dark semi-ovate spots at anterior margin of segment; anal tuft large, consisting of spatulate, fulvous, fuscous-tipped scales; thorax beneath variegated light buff and plumbeous, and lightly clothed with long, white hairs; fore coxa fuscous powdered with light grey; mid- and hind coxae plumbeous; femora and tibiae fuscous above, white beneath, femora with a thick fringe of black hair beneath, mid- and hind tibiae with a white pre-apical ring; tarsi pale buff above, white beneath. Forewing above fuscous, palest in costal area; a sinuate, semihyaline, white fascia of irregular width, beginning behind R_{3+4}, forming an outwardly pointed V in cell R_4, expanded in each of cells R_5 and M_1 to form a long acute tooth basad and a short obtuse one distad, angled outward in each of cells M_2 and M_3, retracted along posterior side of Cu_1 to its origin from cell, there greatly broadened along

lower margin of cell to form a basad-directed tooth before origin of Cu_2, then narrowed to inner margin; the fascia bordered with blackish fuscous and its sinus opposite end of cell filled with blackish fuscous; fringe fuscous. Hind wing semihyaline white; a small black dot at lower angle of cell; a diffuse, grey, costal fascia, and a well-defined terminal blackish-fuscous fascia, narrowing somewhat to tornus; fringe light buff, with a broad fuscous line in its basal half. Forewing below with white fascia as above; the entire area anterior to and basad of fascia blackish-fuscous, except for a diffuse white triangle in baso-posterior sinus of fascia adjacent to margin; area beyond fascia dark fuscous, powdered with grey except for a narrow zone adjacent to fascia. Hind wing beneath as above, but with outer half of marginal band powdered with light grey. Expanse 36 mm.

Male genitalia as figured.

Holotype, male, Kenscoff, Haiti, 4,300 ft., May 3, 1937, Roys, type lot No. 145, Carnegie Museum, Pittsburgh.

This species is probably best placed in the *nitidalis* group, but is distinguished from others of the group by the broader wings and the configuration of the white fascia.

Botyodes borneensis, new species

Figs. 3, 14

Head above pale yellow, frons brownish at the anterior angles; vertex with a bright-yellow tuft; proboscis scaled with yellow at base; palpi brown, labial palpus whitish at base beneath; eye brown, mottled with fuscous; antenna yellow-scaled above; body bright yellow above and below; legs bright yellow. Wings above bright yellow. Forewing above with a weak, broken, oblique, faintly arcuate, fuscous, antemedial line, obsolescent in one specimen; orbicular a fuscous dot; reniform small lunate, fuscous, filled with ground colour; postmedial inwardly oblique, consisting of three dark dots behind costa, fused in one specimen, followed by a line or row of dots from posterior angle of cell to middle of posterior margin; a broad brown zone, with obliquely sinuous inner edge from costa before apex to posterior margin at three-fourths; traces of two yellow subapical lunules; fringe dark brown. Hind wing above with a weak discocellular annulus; an oblique fuscous band from middle of costa to middle of inner margin, slightly interrupted in middle and followed by some grey dusting beyond cell; a greyish-fuscous subapical patch, shading into a brown apical patch; a row of brown dots connected by traces of a grey, zigzag line from subapical patch to just before anal angle; fringe dark brown. Under side as above, but with transverse bands hardly indicated. Expanse 40 to 45 mm.

Female genitalia. Ovipositor rather narrow, densely setose; apophyses slender; periostial region membranous, densely studded with long setae with specialized bases; ductus bursae folded, with a heavily sclerotized collar, ductus expanding gradually into the large membranous bursa.

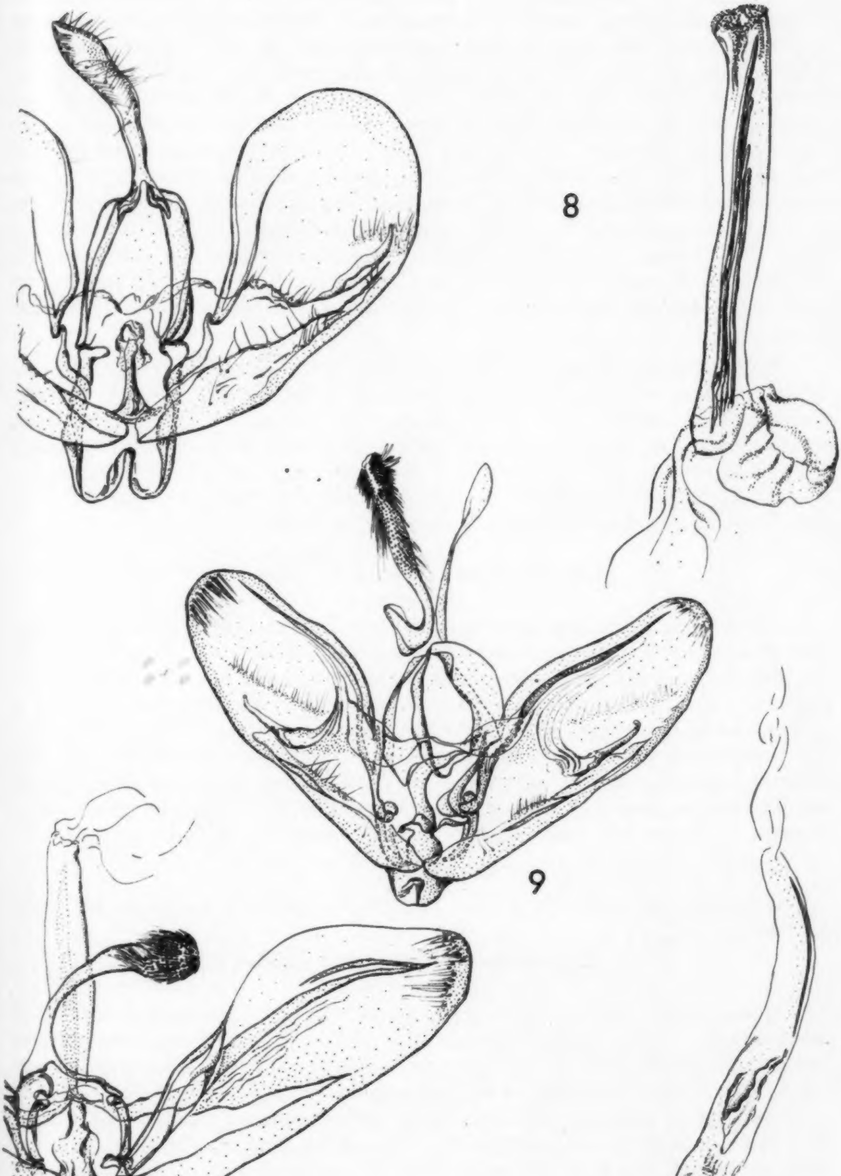
Holotype, female, and two female paratypes, Mt. Kinabalu, Borneo. Holotype and one paratype in Berlin Museum, one paratype, type No. 6919, C.N.C.

This species closely resembles *Botyodes principalis* (Leech) but differs in the terminal brown band of the forewing, which extends broadly to the costa, instead of tapering abruptly to the apex, as in *principalis*, and also in the more nearly continuous transverse lines, especially the postmedial line of the hind wing.

Hedyleptopsis, new genus

Type species: *Hedyleptopsis flava* Munroe

Frons oblique, somewhat flattened; labial palpus upturned, first and second joints with deep, compressed scaling, third joint short and blunt, almost con-



Figs. 8-10. Male genitalia. 8, *Glyphodes aurantivittalis;* 9, *Diaphania antillia,* penis omitted; 10, *Hedyleptopsis flava.*

cealed in scales of second; maxillary palpus prominent, weakly dilated with scales distally; proboscis long and prominent; antenna filiform, nearly as long as wing; eye large; body and legs slender; praecinctorium deeply bilobed. Forewing subtriangular; R_1 from cell before middle, R_2 from near apex of cell, running close to R_{3+4}; R_3 and R_4 long-stalked, weakly divergent; R_5 basally curved and approximated to R_{3+4}; M_1 from near anterior angle of cell; cell not much more than half length of wing; M_2, M_3 and Cu_1 from close together at posterior angle of cell; M_2 and M_3 approximated basally; Cu_2 from cell at three-fourths; anal loop large, closed and distinct. Hind wing short in proportion to forewing; Sc and R_s briefly anastomosed; R_s and M_1 briefly stalked; cell less than half length of wing; discocellular angled in middle, anterior half erect, posterior half outwardly oblique; M_2, M_3 and Cu_1 from posterior angle of cell, M_2 and M_3 strongly approximated, M_3 and Cu_1 weakly so; Cu_2 from cell at three-fourths; three anals present.

Male genitalia. Uncus slender basally; dilated, somewhat compressed, and densely spinose distally; tegumen moderately broad, weakly domed; vinculum narrow, juxta small; valve of moderate size, ear-shaped, with a subcostal strengthening bar, without armature; penis moderately long, cylindrical weakly sclerotized on one side, with a short, flat cornutus. Only the type species is known to me. *Hedyleptopsis* is perhaps related to *Omiodes*, but lacks the prominent clasper that uniformly occurs in that genus.

Hedyleptopsis flava, new species

Figs. 4, 10

Head, palpi, body, legs, antenna and wings orange-yellow. Wing markings fuscous brown. Forewing above with antemedial line obscure, oblique; orbicular dot and discocellular lunule prominent, solid; postmedial line faint, straight and outwardly oblique from costa to Cu_2, then abruptly retracted to behind angle of cell and oblique outward then inward to posterior margin; a faint subterminal line; fringe dark fuscous. Hind wing above with diffuse discocellular spot, very obscure postmedial line, straight from costa to Cu_2, then retracted to behind cell and oblique to near anal margin; subterminal line and fringe as on forewing. Beneath as above, but with markings fainter. Expanse 36 mm.

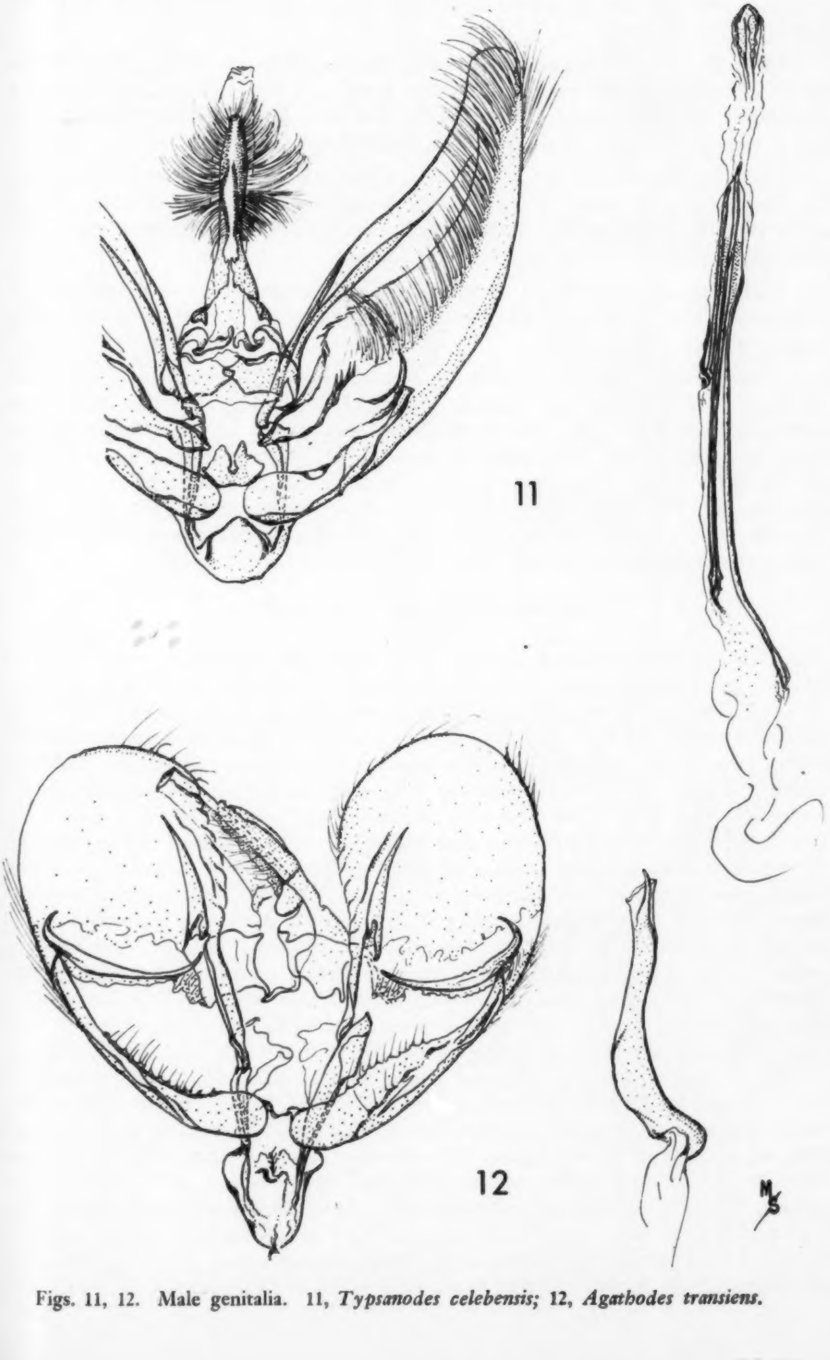
Genitalia as described for the genus.

Holotype, male, Tonsea Lama, Tontano Menado, N. Celebes. In Leiden Museum.

Typsanodes celebensis, new species

Figs. 5, 11, 15

Head orange; some black scaling towards tip of labial palpus and on its inner surface; a large purplish-fuscous spot on frons; base of proboscis purplish fuscous; antenna fuscous-scaled above, yellow beneath; eye fuscous mottled with black; thorax above orange, with conspicuous metallic, blue-black spots on patagium, tegula and disc; first segment of abdomen above orange, with a large, blue-black, mid-dorsal spot; abdomen above greyish fuscous, tipped with orange; body below and legs dark greyish fuscous; body tipped with orange. Forewing above dark greyish fuscous; a small orange basal patch, containing a metallic blue-black spot; a white sub-basal spot, connecting with a yellowish-buff streak on anal loop; a large, round, antemedial, white spot behind cell; a smaller, oval, white, medial spot in and before cell; a large, round, white spot on discocellulars; veins from R_4 to Cu_2 each with a pale-buff streak on each side of the vein and a yellowish-brown streak on it; anals each with a yellowish-buff streak; fringe



Figs. 11, 12. Male genitalia. 11, *Typsanodes celebensis;* 12, *Agathodes transiens.*

dark fuscous. Hind wing with disc white, base and all margins broadly blackish fuscous; fringe dark fuscous. Under surface dark fuscous; forewing with a round, white spot on discocellulars; hind wing with a white patch as above. Expanse 37 to 42 mm.

Male genitalia. Uncus short and rounded, sparsely setose dorsally; transtilla broad laterally, slender in middle; valve broad and heavily sclerotized, with a prominent, toothlike clasper; juxta slender and oval, laterally strengthened; penis rather long and slender, with two long, slender cornuti.

Female genitalia. Ovipositor densely pilose, with a row of long setae around the rim; apophyses rather slight; ductus bursae very long and slender, densely spiculose for a considerable distance near bursa; bursa oval, membranous, very minutely spiculose, with a small, round signum.

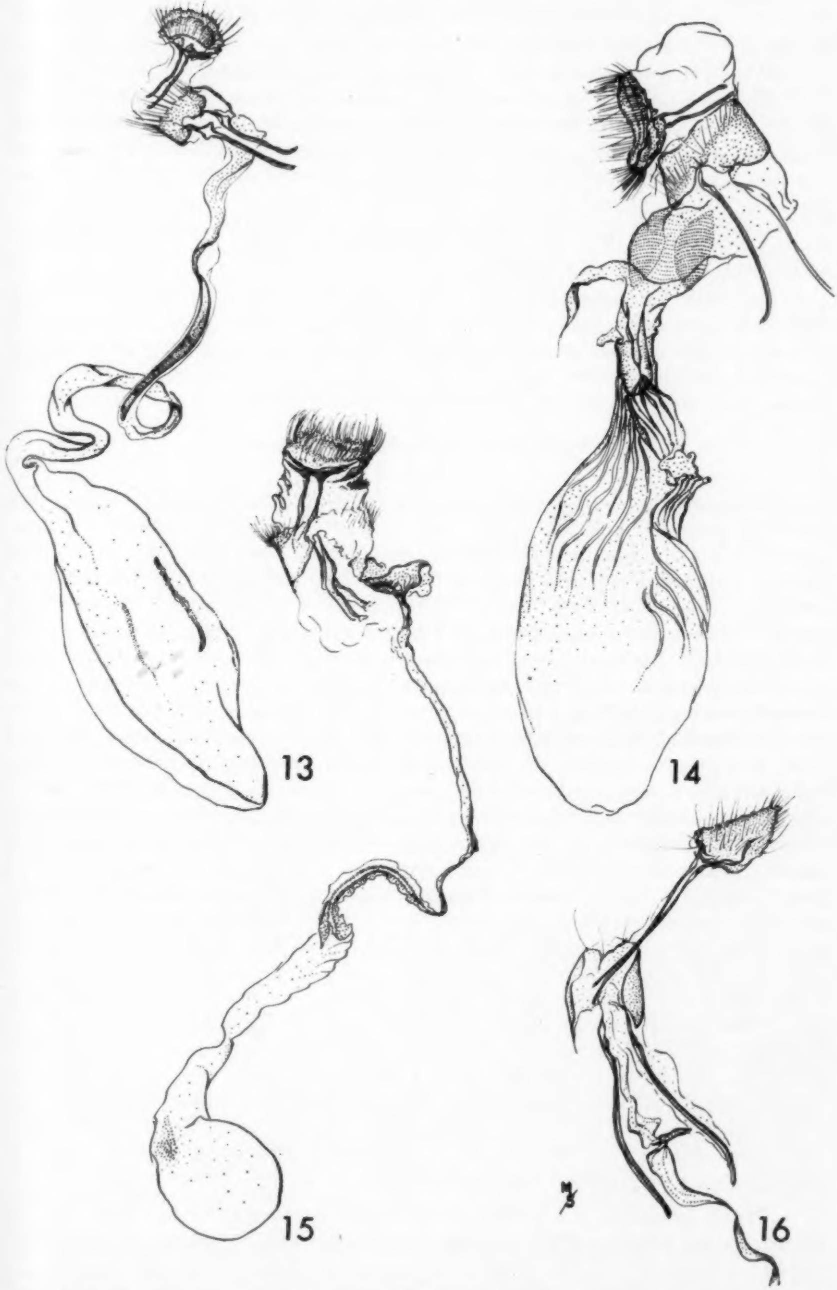
Holotype, male, allotype, female and one female paratype, Minahassa, N. Celebes, P. J. v. d. Bergh. Holotype and allotype in Leiden Museum. Paratype, type No. 6920, C.N.C.

This species is closely related to *Typsanodes hillalis* (Schaus), new combination, = *Phostria hillalis* Schaus, 1927: 313, Pl. 2, Fig. 2, from Luzon, but differs in having the pale rays of the forewing divided by dark stripes on the veins, in details of the basal markings and in the distribution of black and white on the hind wing. These two species are more robust than typical species of *Typsanodes*, but palpi, wing venation and genitalia agree reasonably well. *Nevrina*, which is also closely related, has the frons obliquely prominent and the cell of the hind wing unusually short.

Agathodes transiens, new species

Figs. 6, 12

Frons brown, bordered laterally with pale buff; vertex light brown; palpi brown, labial palpus pale buff at base beneath; antenna simple and filiform; thorax above light brown, scaling of tegula reaching basal segments of abdomen; abdomen variegated light and dark brown (greasy in type); thorax beneath pale buff; front femur and tibia purplish brown; front tarsus and middle and hind tibiae and tarsi pale buff. Forewing long and narrow; costal area to behind radius purplish grey from base to apex; basal area purplish grey; a cinnamon-brown, strongly inwardly oblique, antemedial line from middle of cell to posterior margin near base, this line shading distally into the pale-buff, heavily cinnamon-scaled, posteromedial area; orbicular small, anvil-shaped, dark fuscous; reniform lunate, purplish grey; a longitudinal purplish-grey streak on Cu from base to end of cell; anal veins narrowly purplish grey; an inwardly oblique, dark-fuscous, medial streak from Cu behind reniform to posterior margin; postmedial line indicated anteriorly by a pale, outwardly oblique shade on costal area, becoming a blackish-fuscous, strongly outwardly oblique line at R_5, becoming abruptly erect at M_1, curving in a series of scallops from M_2 basad to Cu_2 behind cell, then inwardly oblique to inner margin and joined along it to medial streak; postmedial line followed by a white zone except between M_1 and M_3; the broad median bend of postmedial line beyond cell filled almost entirely with purplish grey; terminal area brown, darker in middle and at tornus and with all veins purplish fuscous; basal half of fringe purplish fuscous, distal half brown to Cu_1, white from Cu_1 to tornus. Hind wing above translucent white; some fuscous dots on veins; fuscous terminal dots at vein-ends; fringe white, with a grey mid-line, darkest opposite veins. Forewing beneath brownish fuscous; anal area pale grey; reniform and orbicular faintly darker fuscous; postmedial line faintly indicated, followed by a



Figs. 13-16. Female genitalia. 13, *Glyphodes aurantivittalis;* 14, *Botyodes borneensis;* 15, *Typsanodes celebensis;* 16, *Syngamilyta nympha.*

pale shade, the latter broadest on costa; apical area pale; fringe grey anteriorly, fuscous in middle, basally fuscous and distally white in tornal area. Hind wing as above, costa pink. Expanse 39 mm.

Male genitalia. Uncus well developed, narrowly triangular with a distal, ventral, semi-membranous, expansion and extension bearing a marginal zone of long, horizontally radiating setae; gnathos a narrow belt; transtilla broad, somewhat narrowed medially; juxta small, deeply emarginated dorsally; valve long and tapering, with a costal thickening and with an anteriorly curved, spinelike clasper; penis small and unarmed.

Holotype, male, Puente Villa, Yungas, Bolivia, 1,200 m., Dec. 12-20, 1955, L. E. Peña, type No. 6948, C.N.C.

This remarkable species is one of the most primitive of its group, preserving fully developed antemedial and postmedial lines and reniform and orbicular spots; also the uncus is much more strongly developed than in other species I have examined and the tegumen lacks the paired posterolateral processes. The species shows some resemblances to *Liopasia*, perhaps indicating a real relationship.

Syngamilyta nympha, new species

Figs. 7, 16

Frons brown dorsally, black on sides; vertex reddish brown dorsally, white on sides; palpi black, labial palpus buff beneath; eye brown with black spots; proboscis brown; antenna with first segment white, shaft buff, middle segments banded with fuscous; thorax above with mixed brown and black scales anteriorly, medially white, posteriorly black; abdomen above white, with irregular black patches anteriorly and medially; body beneath white; legs white, narrowly banded with blackish fuscous. Forewing above shining white; a small black basal spot; a broad black sub-basal spot from costa to posterior margin, its outer margin arcuate and paralleled at a short distance by the narrow black antemedial line; orbicular an outwardly oblique vinous-red dash in cell; reniform vinous red, fused with an irregular, vinous-red, postcellular patch; postmedial line narrow, black with some vinous-red interceptions, weakly oblique inward to R_4, then weakly oblique outward to M_2, there offset distad and erect to Cu_2, then retracted to base of Cu_1, and continued sigmoidally to posterior margin; a rhomboidal black apical patch from costa to middle of cell M_1, dusted with white anteriorly, separated from termen by a white line; a subquadrate black patch with some vinous scaling, on inner margin just before tornus, this patch fused with the retrorse segment of postmedial line; fringe white, with a black line in the basal half apically and tornally. Hind wing above white; black basal patches in cell and anal space; a mixed black and buff discocellular bar; postmedial line black, diffuse posteriorly, lunate from cell R_1 to vein M_2, there offset distad then oblique basad to Cu_1, there strongly inset and straight to near anal margin, there bent basad; a black patch from apex to cell M_2, separated from termen by a white line; a triangular, inwardly infuscated, yellowish-buff, subterminal patch in cells Cu_1 and Cu_2; fringe white, with a broken black basal line in basal half, and some fuscous suffusion in distal half opposite cells Sc and Cu_1. Under side like upper side, but with all markings blackish fuscous. Expanse 17 mm.

Female genitalia. Ovipositor rather small and compressed, lobes sparsely setose; ductus bursae with a narrow, moderately long, sclerotized collar; bursa slender.

Holotype, male, Rio Yacuna, Espiritu, 250 m., Bolivia, May 2, 1954, W. Forster, in Bavarian State Zoological Collection.

Readily separable from other described species–*S. leucinodalis* Strand ? = *S. pretiosalis* (Schaus), new combination, described in *Trithyris*, ? = *S. pehlkei* (Hering), new combination, described in *Desmia*, and *S. apicolor* (Druce), new combination, described in *Syngamia* – by the black, not brown, sub-basal patch of forewing, with arcuate, not oblique, outer border, by the distinct antemedial line, by the oblique, not dotlike orbicular, and by the separation and contrasting colour of the apical and tornal patches.

Summary

The following seven species and one genus of Pyraustinae are described as new: *Glyphodes aurantivittalis*, Sumatra; *Diaphania antillia*, Haiti; *Botyodes borneensis*, Borneo; *Hedyleptopsis* [new genus] *flava*, Celebes; *Typsanodes celebensis*, Celebes; *Agathodes transiens*, Bolivia; *Syngamilyta nympha*, Bolivia. *Phostria hillalis* Schaus is transferred to *Typsanodes* and *Trithyris pretiosalis* Schaus, *Desmia pehlkei* Hering and *Syngamia apicolor* Druce to *Syngamilyta*.

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Two New Species of *Cyrtinus* LeConte (Coleoptera: Cerambycidae)

By Henry F. Howden

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In a recent paper (1959), I described two new species of *Cyrtinus* and gave a key to the New World species of the tribe Cyrtinini. Two additional new species have been discovered, one from Jamaica and one from the Big Bend region of Texas. The Jamaican species is most closely related to *Cyrtinus sandersoni* Howden, while the Texas species appears to be near *Cyrtinus pygmaeus* (Haldeman).

As in a number of species in the genus, there is no good way to distinguish the sexes by external morphological characters. Since dissection often destroys the characteristic form of the species, no attempt has been made to sex all specimens. Both males and females are represented in the Jamaican series, whereas only females seem to be present in the Texas species.

Cyrtinus farri, new species

Fig. 1

Holotype.–Length 2.5 mm., greatest width 0.8 mm. Head brown; pronotum, except basal constriction, brownish-black; elytra brownish-black to black, except for a narrow, transverse, testaceous band at basal fourth. A small, recumbent tuft of white setae on the elytra, anterior to testaceous band and midway between margin and suture; a transverse band of white setae posterior to testaceous band and extending five-sixths of the distance from margin to suture. Abdomen and apical halves of hind femora brownish black; remainder of ventral surfaces, legs, antennae, and basal constriction of pronotum testaceous to brown. Meso- and meta-sternum each with posterior, lateral patches of recumbent, white setae.

Head approximately as long as wide. Labrum small, very shallowly emarginate; clypeus short and transverse. Frons convex; sparsely, finely, setigerously punctate; surface distinctly granulate except near antennal bases; longitudinal median suture of frons evident but not impressed. Vertex distinctly

granulate; scattered, fine setigerous punctures present on anterior half. Each eye small, coarsely granulate, divided; eyes separated from each other on vertex by twice width of emargination of eyes in front; lower lobe of eye approximately twice the size of upper lobe. Antennae 11-segmented, about as long as the body; outer edges of segments with numerous, fine, yellowish setae; inner edges with fewer but larger testaceous setae. Basal segment elongate, narrowed basally (Fig. 1).

Pronotum two-ninths longer than wide, distinctly narrower at base than apex; sides nearly parallel anteriorly, slightly constricted at apical third, strongly constricted at basal fifth. Disc strongly shining except in anterior fifth, which is finely granulate; minute, seta-bearing punctures widely, irregularly scattered over disc, particularly anteriorly; basal constriction finely granulate and moderately punctate, the punctures bearing whitish setae.

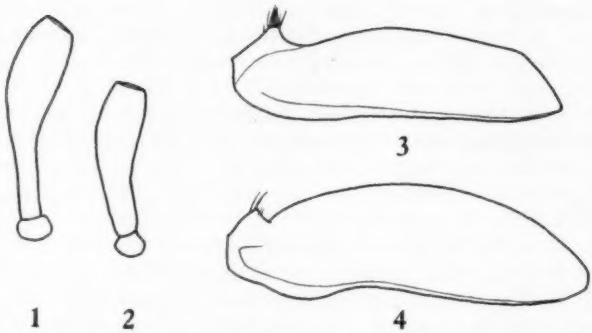
Scutellum finely setate-punctate. Elytra twice as long as wide, approximately one-fifth wider than pronotum; humeri distinct; sides parallel at base, slightly expanding to apical third, then arcuately attenuate to apices, the latter rounded. Discal surface shining; narrowly, shallowly, transversely impressed at basal fourth in area of transverse testaceous band. Each elytron with a vague, basal, rounded tumidity indicating the basal tubercle, each swelling with a single, long, erect, blackish seta arising from its center; numerous, small, recumbent, setae extending from the humeri to suture. Elytra feebly convex in apical two-thirds; surface impunctate except for 12 to 15 large punctures in transverse band. Approximately six long, erect, black setae (flying-hairs) on each elytron behind the transverse impression.

Beneath generally shining; abdominal segments each with a transverse row of white setae; apical segment with numerous, white setae near apex. Each femur strongly clavate; the club flattened laterally, with a band of white setae along the outer margin.

Type Material.—Holotype; Christiana, Manchester, Jamaica, B.W.I., June 11, 1959, T. H. Farr; in Canadian National Collection (No. 7039). Paratypes: 24; 11, same data as holotype; 11, same data as holotype except collected on June 12, 1959; one, 2 mi. S. Moneague, Jamaica, June 27, 1958, M. W. Sanderson (J58-27); one, Morces Gap, Jamaica, July 22, 1958, M. W. Sanderson (J58-29). Paratypes in the Canadian National Collection, Illinois Natural History Survey Collection, The Institute of Jamaica, and the United States National Museum.

Variation in the paratypes is considerable. Length ranges from 2.3 to 2.9 mm. and greatest width from 0.7 to 0.8 mm. The labrum is sometimes truncate instead of vaguely emarginate; the frons in a few specimens is largely smooth, only the vertex being noticeably alutaceous; the longitudinal median line of the frons is absent in two specimens, only vaguely indicated in some others. Antennal color, which is nearly uniformly testaceous in the type, more often is testaceous on the basal portion of each segment and dark brown at the apex. On two specimens the patch of white setae anterior to the testaceous band on the elytra is indistinct; on other specimens there is a large, moderately distinct patch of white setae on the posterior fourth of the elytra, midway between the suture and margins. Ventral setae show some variation, particularly on the abdomen, where in some cases they are absent except on the terminal segment.

Cyrtinus farri is most closely related to *C. sandersoni* Howden, and less so to *C. schwarzi* Fisher. *Cyrtinus farri* will key out to *sandersoni* in my 1959 key, but differs in the following respects: frons and vertex granulate and finely punctate, anteriorly; basal antennal segment longer and more constricted basally



Figs. 1-4. *Cyrtinus* spp. 1, *C. farri*, n. sp., basal segment of antenna. 2, *C. sandersoni* Howden, basal segment of antenna. 3, *C. pygmaeus* (Haldeman), lateral view of left elytron. 4, *C. beckeri*, n. sp., lateral view of left elytron.

(Figs. 1 and 2); pronotum granulate anteriorly and much more finely punctate; elytra with tuft of white setae before transverse depression, and posterior band of white setae heavier and more transverse; scutellum lacking white setae; and club of femur with band of white setae on outer margin. *Cyrtinus farri* is darker than *C. schwarzi* and lacks the raised sutural intervals.

This species is named in honor of Dr. T. H. Farr, Science Museum, Institute of Jamaica, Kingston, Jamaica, who collected most of the type series and kindly made it available to the writer.

Cyrtinus beckeri, new species

Fig. 4

Holotype.—Length 3.3 mm., greatest width 1.2 mm. Head, pronotum, elytral tubercle, apical four-fifths of elytra, and abdomen brownish-black to black; remaining ventral surface, legs, and antennae tan to brown; each antennal segment darker apically. Each elytron with a patch of white setae posterior to the tubercle and extending to suture; oblique band of white setae also present posterior to testaceous area on anterior fifth of elytra, the band extending from margin three-fourths of the distance to suture.

Head approximately as long as wide. Labrum small, broadly rounded; clypeus very short and transverse. Frons convex, granulate with a few scattered punctures each bearing a long, black setae; a small, round fovea midway between antennal insertions; vertex with scattered fine punctures near eyes, impunctate areas granulate, except for smooth, shining midline. Each eye small, coarsely granulated, divided; eyes separated from each other on vertex by twice width of emargination of eyes in front; lower lobe of eye only slightly larger than upper lobe. Antennae 11-segmented, slightly longer than the body; basal segment not greatly constricted in basal half, second segment one-fourth as long as basal segment; outer edges of segments with numerous, fine, testaceous setae, inner edges with a few long, brown setae.

Pronotum one-tenth longer than wide, distinctly narrower at base than apex; sides nearly parallel anteriorly, very slightly constricted at apical third, strongly constricted at basal fourth, then generally parallel to base; disc strongly convex, finely granulate on anterior fourth, otherwise smooth and shining between the sparse, fine, seta-bearing punctures; basal constriction granulate and rather coarsely, closely punctate; punctures bearing tan, recumbent setae.

Scutellum covered apically with recumbent, white setae. Elytra fused, about 1.7 times as long as wide, two-sevenths wider than pronotum; humeri small but distinct; sides of elytra expanding from humeri to middle, then arcuately attenuate to apices, which are rounded. Elytra in lateral profile (Fig. 4) more convex than in *C. pygmaeus* (Fig. 3), evenly arcuate from tubercles to apices. Disc shining, impressed only from humeri to posterior bases of tubercles, impressions not extending to suture. Each elytron with a distinct, basal, conical tubercle, surmounted by three or four long black setae. Coarse punctures present in a semicircle at the base of each tubercle, otherwise elytra generally impunctate. Long, erect, black setae (flying hairs) present laterally and on posterior five-sixths of elytra. Metathoracic wings nonfunctional, reduced to small pads.

Beneath shining; meso- and meta-sternum punctate and with white setae laterally; abdominal segments one to four alutaceous laterally and with scattered, testaceous setae; fifth abdominal segment alutaceous, numerous whitish setae near apex. Each femur moderately clavate; the club occupying the apical half, flattened laterally.

Type Material.—Holotype; Pine Canyon (5,000 ft.), Chisos Mts., Big Bend Nat. Pk., Texas, May 10, 1959, H. Howden and E. Becker, on *Acer grandidentatum;* in United States National Museum. Paratypes: 14; six, same data as holotype; one, same data as holotype except collected on May 7, 1959; seven, Boot Spring (7,000 ft.) Chisos Mts., Big Bend Nat. Pk., Texas, May 18, 1959, H. Howden and E. Becker, on *Acer grandidentatum* (six) and *Quercus* sp. (one). Paratypes in the Canadian National Collection (No. 7040) and in the collection of J. N. Knull.

Variation in the paratypes is moderate. Length ranges from 2.4 to 3.5 mm. and greatest width from 0.9 to 1.4 mm. Color of head, pronotum, and apical five-sixths of elytra varies from very dark brown to black, with darker specimens having correspondingly darker appendages. Dorsal convexity of elytra varies somewhat, but the elytra of all specimens appear evenly arcuate when viewed in lateral aspect. Variation in density of pubescence is moderate, particularly on the pronotum, but the elytral pattern appears constant. The small fovea on the frons between the antennae is lacking or reduced to a small puncture in a few cases.

Cyrtinus beckeri keys out in my 1959 key to *C. pygmaeus* (Haldeman), to which it seems most closely related. It can be readily separated from *C. pygmaeus* by its more convex elytra when viewed laterally (Figs. 3 and 4). Also the anterior edge of the elytral tubercles touch the base of the elytra in *C. beckeri*, and the elytra are fused, the metathoracic wings being reduced to small pads. *Cyrtinus pygmaeus* has well-developed wings; it seems to fly fairly frequently, as I have taken several specimens in flight.

The habitat of *Cyrtinus beckeri* appears to be restricted to several canyons on the east slopes of the Chisos Mountains. Most of the specimens were taken by beating dead twigs of maple (*Acer grandidentatum* Nutt.), but one was taken on oak (*Quercus* sp.). The maples grew in moist areas at altitudes of from 5,000 to 7,000 feet and appeared to have a wider range than did the *Cyrtinus*. Maples were fairly common in Pulliam Canyon on the northwest side of the Chisos Mountains, but extensive collecting in that canyon did not procure *Cyrtinus*. Most of the specimens were taken in mid-afternoon. Collecting in one grove of maples in Pine Canyon in mid-morning yielded nothing, but the same grove yielded five specimens in mid-afternoon. No larvae or mining in the twigs were discovered.

This species is named in honor of my colleague, Dr. E. C. Becker, who discovered the first specimen of this interesting species.

Summary

Two new species of long-horned beetles, *Cyrtinus farri*, from Jamaica, and *Cyrtinus beckeri*, from the Chisos mountains of Texas, are described. A brief discussion of the habits of *Cyrtinus beckeri*, which was collected on maple (*Acer grandidentatum*), is included.

Reference

Howden, H. F. 1959. Description of two new species of *Cyrtinus* LeConte; with a key to the New World Cyrtinini (Coleoptera: Cerambycidae). *Canadian Ent.* 91: 372-375.

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A Roll-Up Field Cage for Insects

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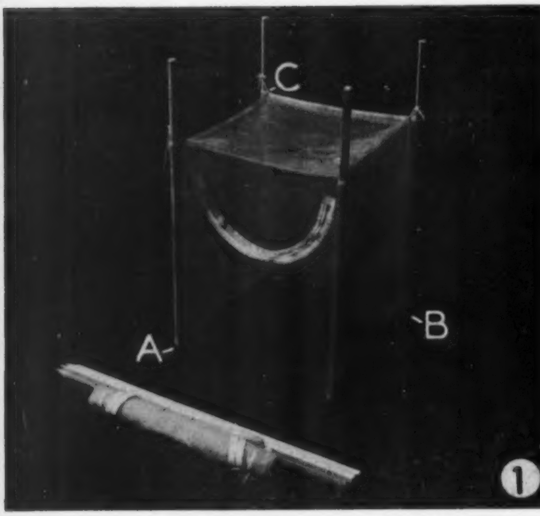
Most conventional field cages are bulky and difficult to handle, even when they can be partially disassembled. Consequently, a cage that has little weight and is easily collapsed and rolled into a small bundle would be advantageous. This paper describes such a cage that weighs only three pounds and is easily rolled into a bundle about four inches in diameter.

The cage (Fig. 1) is an inverted bag reinforced at its lower edges and supported by four wooden stakes. It is of natural-coloured saran screen with 20 openings per inch and .012 inch diameter strands. The inside dimensions are 27 by 27 by 36 inches. The entrance is a semi-circular opening fitted with a 36-inch nickel-plated slide fastener.

The four sides of the cage are of a continuous piece of screen spliced at one corner. A loop, five inches in circumference, is sewn into each corner to receive a wooden stake one inch square. A separate piece of screen forms the top. The seams and exposed edges are reinforced with heavy binding tape and sewn with nylon thread. A nylon shoelace (Fig. 1, C) is attached to each top corner to enable the corners to be tied to the stakes.

Fig. 2 shows a corner of the cage in detail. The reinforcing strips along the bottom edges are of 20-gauge aluminum four inches wide by 26 inches long bent over the screen and riveted in place. They are one inch shorter than the side of the cage to enable the cage to be folded. This is shown at D. A pliable plastic washer (E), 1¼ inches in diameter and about 1/16 inch thick, is placed on each side of the screen to protect it from chafing by the corners of the aluminum when the cage is folded.

The cage is collapsed and rolled by first removing the four stakes and then bringing corners A and B together. It is then folded in the centre to bring the aluminum strips together in the form of a sandwich, around which the screen is rolled. A rolled cage is shown in the foreground of Fig. 1. Its volume is only about 1/50 of its full size.



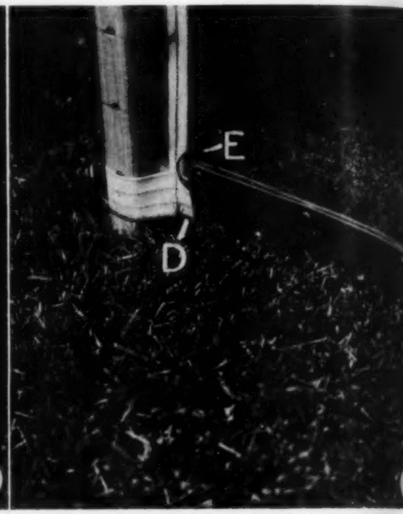


Fig. 1. Cage erected in field. Foreground, cage rolled for storage.
Fig. 2. Corner of cage showing details of fabrication.

Besides being easily handled because of its little weight and bulk, this cage has the additional advantage that it modifies the inside environment less than do many conventional types of cages. For example, when the outside air temperature over a two-week period ranged between 26 and 32°C. the temperature within was only a maximum of 2°C. higher. Recordings were made at noon on bright sunny days. Natural lighting is less impeded by the translucent strands of the natural-coloured saran screen than by those of many other types of screen. Moreover, shading is reduced by the use of a minimum of structural supports. A number of these cages were tested during the summer of 1959 and found to be eminently satisfactory for entomological field work.

Summary

A roll-up field cage and the method of fabrication are described and illustrated. This cage is relatively light, is easily handled and modifies environment to a lesser degree than do most conventional types of cages.

(Received December 7, 1959)

A New Species of *Matsucoccus* Cockerell (Homoptera : Coccoidea)

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Ottawa, Ontario

Matsucoccus is composed of species of scales that are completely restricted to species of *Pinus* L. Inclusive of the species described herein, nineteen species have been described, mostly from North America; but hitherto the genus has been unknown in Canada.

Matsucoccus macrocicatrices, new species

First Stage Larva or Crawler.—Antenna seven-segmented, segments I, II, VII with pointed setae; segments IV and VI each with a long, fleshy, sensory spine at apex. Legs well developed, each trochanter with a seta that is as long as the respective femur. Body without glandular structures. With seven pairs of abdominal spiracles and two pairs of thoracic spiracles. Body without setae except for a row dorsally on each side of the abdomen and some longer ones around anus, the longest of which is as long as the hind femur. Length 0.34-0.6 mm.

Apodous Intermediate Stage.—Circular, oval or pyriform, often slightly tapered toward anal region. Without legs, antennae, setae or glandular structures except for large, complex, poriform plates near spiracles. Mouthparts well developed. With two pairs of thoracic and seven pairs of abdominal spiracles situated at the bottom of deep, cylindrical invaginations where the circular, poriform plates are also located. Integument, smooth, thick, relatively strongly sclerotized. Length when mounted on microscope slides 0.6-1.5 mm.

Female.—Antenna nine-segmented, segments V to IX each with a pair of long, fleshy, sensory spines, those on segment V less well developed. Eyes present, situated just posterior to bases of antennae. Mouthparts absent, represented by a longitudinal fold. Legs and thoracic spiracles characteristic for genus; trochanter with a single short seta; claws with a few, rounded, smooth imbrications near bases. Thoracic region with four or five tranverse rows of bilocular pores, the rows incomplete ventrally. Each segment of abdomen with transverse, dorsal and ventral rows of bilocular pores. Dorsum of abdomen with four transverse groups of cicatrices, each group with 12-30 cicatrices. Cicatrices circular to oval, 18-25.5 microns in diameter. With about 50 multilocular pores situated around the genital orifice; individual pore plate, eight to ten microns in diameter. Dorsal setae short, pointed, five to six microns long. Ventral setae also pointed, 10-23 microns long. Integument membranous, the surface composed of minute, closely spaced, circular nodules. When mounted 3.6-4 mm. long.

Preadult Male.—Without dorsal cicatrices or multilocular pores. Bilocular pores less numerous and slightly larger than in female. When mounted 1.5-1.8 mm. long. Otherwise essentially as in female.

Male.—Antenna ten-segmented, antennal setae mostly slender, pointed, longer than the basal diameters of the segments on which they occur; segments III to X each with four, slender, long, distinctly capitate setae at apex. Antenna 1.35 mm. long. Dorsum of head faintly striated, with two minute, pointed setae near mesal margin of each eye. Mouthparts absent. Prothorax, smooth, without seta, but with numerous, short, slender, blunt, peg-like organs on posterior half. Dorsum of pterothorax, smooth, without setae. Wings normal, forewing with a

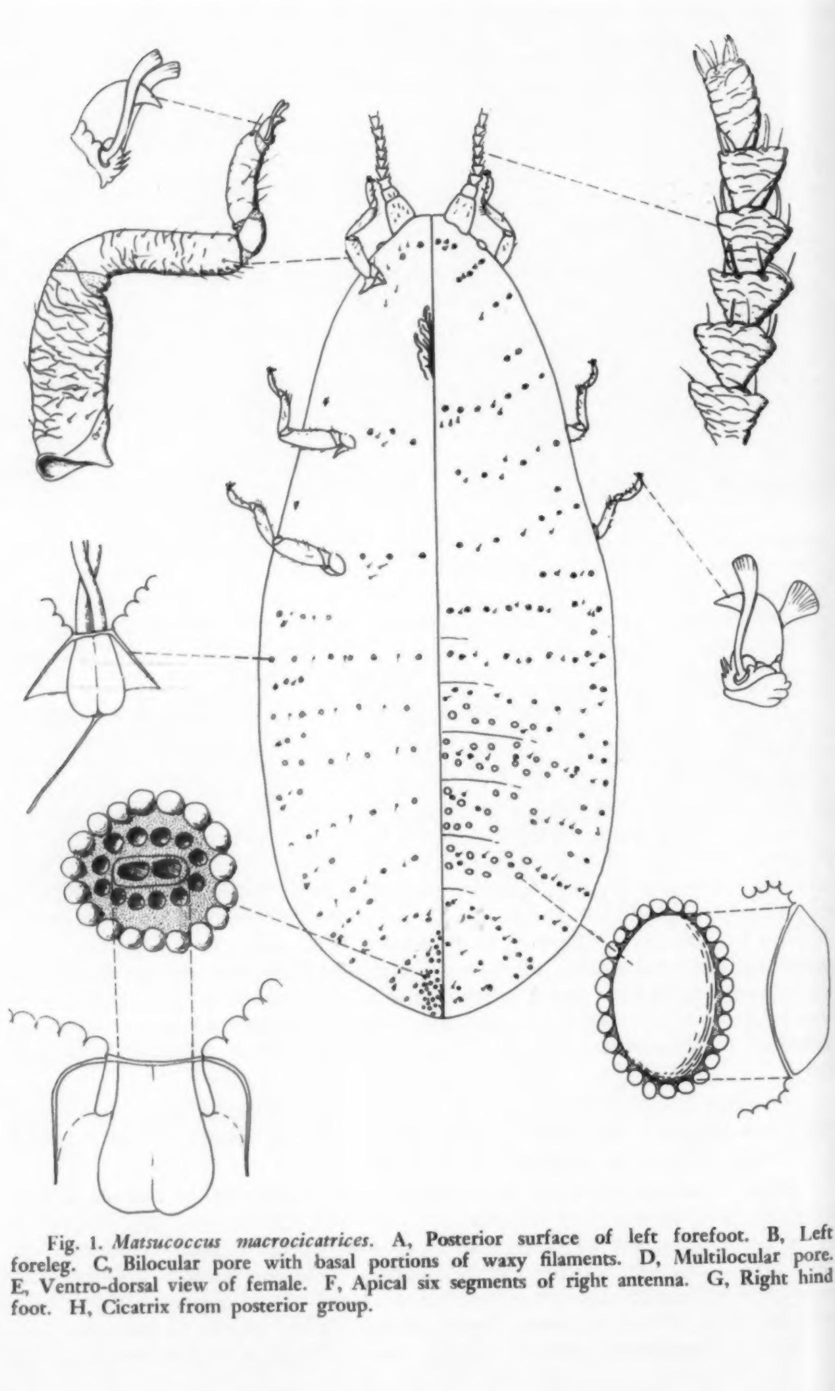

Fig. 1. *Matsucoccus macrocicatrices*. A, Posterior surface of left forefoot. B, Left foreleg. C, Bilocular pore with basal portions of waxy filaments. D, Multilocular pore. E, Ventro-dorsal view of female. F, Apical six segments of right antenna. G, Right hind foot. H, Cicatrix from posterior group.

complex system of closely set transverse ridges extending from longitudinal vein to anterior and posterior margins. Hindwing club-shaped, with a tuft of slender, very long setae near apical margin; 0.25 mm. long. Legs normal, well developed, with numerous, pointed setae that are less than half the apical diameter of hind tibia. Claws normal, untoothed, with the usual two basal tenent hairs. Hind tibia 0.5 mm. long. Hind tarsus exclusive of claw 0.175 mm. long. First abdominal tergum with numerous sensory pegs similar to those that occur on dorsum of prothorax; terga IV-VII and IX each with a single transverse row of short, pointed setae; tergum VIII with patch of multilocular pores of which the orifices are raised on prominent cylindrical tubercles. Venter of abdominal segments each with a single transverse row of pointed setae. Penis narrow, spatulate, 0.275 mm. long. When mounted two mm. long.

Types.—Holotype: Female, Lynedoch, Ontario, June 3, 1958, on *Pinus strobus* L. (N. W. Y. Watson). No. 7070 in Canadian National Collection. Paratypes: 15 females, same data as holotype. Two females, Denbigh, Ontario, June 19, 1959, on *Pinus strobus*, (N. W. Y. Watson). Two females, Fredericton, N.B., May 28, June 26, 1959, on *Pinus strobus*, (G. R. Underwood). 21 first stage larvae, Griffith, Ontario, July 30, 1959, on *Pinus strobus* (N. W. Y. Watson). 11 apodous intermediates, Griffith Lake, Ontario, July 30, 1959, on *Pinus strobus*, (N. W. Y. Watson). 12 apodous intermediates, Denbigh, Ontario, June 19, 1959, on *Pinus strobus*, (N. W. Y. Watson). 17 apodous intermediates, Fredericton, N.B., May 19, 28, June 2, 26, August 6, 1959, on *Pinus strobus*, (G. R. Underwood). 12 preadult males May 19, 28, August 6, 20, 1959, on *Pinus strobus*, (G. R. Underwood). One male, Fredericton, N.B., May 28, 1959, on *Pinus strobus*, (G. R. Underwood).

Comments.—This species is very similar to *M. paucicicatrices* Morrison, which is known only from various species of white pines in western North America. The two species can be distinguished most readily by the differences in the diameters of the dorsal cicatrices in the females. In *M. paucicicatrices* the diameters of the cicatrices range from 4.7 to 6.8 microns and from 18 to 25.5 microns in *macrocicatrices*.

Summary

A new species of *Matsucoccus* is described and illustrated and its structural affinities to other species noted.

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(Received November 24, 1959)

A Simple Freeze-Drying Apparatus for Preserving Plant Materials Treated with Insecticides[1]

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Freeze-drying equipment at this station capable of handling bulk quantities of fresh plant material was designed as a single unit and was therefore unsatisfactory for use with plant materials having insecticide residues because decontamination was difficult and quantitative recovery of the condensate after each run was almost impossible. The condensate may contain a considerable portion of the insecticide and contamination could influence assay results. To overcome these problems a simple apparatus, modified after the Cole-Palmer bulk freeze-dryer (Cole-Palmer Instrument and Equipment Company, Chicago, Illinois), was constructed from readily available materials with a minimum of machine-shop labor.

This apparatus consists of three units, a drying chamber, moisture trap, and ice bath, as shown in Fig. 1. A four-litre stainless-steel beaker with a ¾-inch hole machined in the bottom serves as the bulk drying chamber. The drying rack, which fits inside the beaker with ¼-inch clearance, consists of four adjustable ¼-inch-thick Plexiglas (Rohm and Haas Company of Canada Limited, West Hill, Ontario) shelves mounted on a threaded brass rod. Four ¾-inch brass feet threaded into the bottom shelf serves as the stand and allows vapour circulation in the chamber. A band of heavy rubber inner-tubing stretched over the mouth of the beaker is used as a gasket and when coated with silicon vacuum grease gives a satisfactory seal with the ¾-inch-thick Plexiglas lid. Fresh-frozen plant material to be dried is finely broken up and placed on the shelves of the drying rack. If the latter has been precooled the plant material remains frozen when the rack is placed in the drying chamber. When contamination occurs from insecticides the drying chamber and rack can be dismantled easily for cleaning.

The moisture trap is a 1000-ml. Pyrex filter flask, mounted below the drying chamber. The two are connected by means of a 6½-inch length of ¾-inch glass tubing inserted through and held in place by an oversized (No. 13 Neoprene) stopper. The tube extends ⅛ inch into the drying chamber and approximately four inches below the side arm of the filter flask. It should not extend too far into the filter flask, otherwise, the condensate may freeze in it and block the system. Silicon vacuum grease on both sides of the stopper gives an effective seal and both containers are held in place by clamps on a large laboratory support stand. The condensate, which is trapped and frozen in the moisture trap, can be recovered quantitatively and the glassware readily decontaminated or replaced.

The insulated bath is made from a one-gallon tin placed in a three-gallon crock. The top of the tin is held flush with the crock and the space surrounding the tin is filled with fine-grade Vermiculite (Insulation Industries Limited, Calgary, Alberta). A ring of 3/16-inch-thick oil-tempered Masonite covers the insulation and is sealed to both containers with plastic electricians tape to prevent excess moisture from penetrating the insulation. Isopropyl alcohol and dry ice in the ratio of 1:4 serve as the coolant and a Styrofoam (Dow Chemical Company of Canada Limited, Toronto, Ontario) lid covers the ice bath to prevent undue heat exchange.

In operation, the side arm of the filter flask is connected by means of heavy-walled rubber tubing to a McLeod gauge and, through calcium chloride and

[1]Contribution from the Entomology Section.

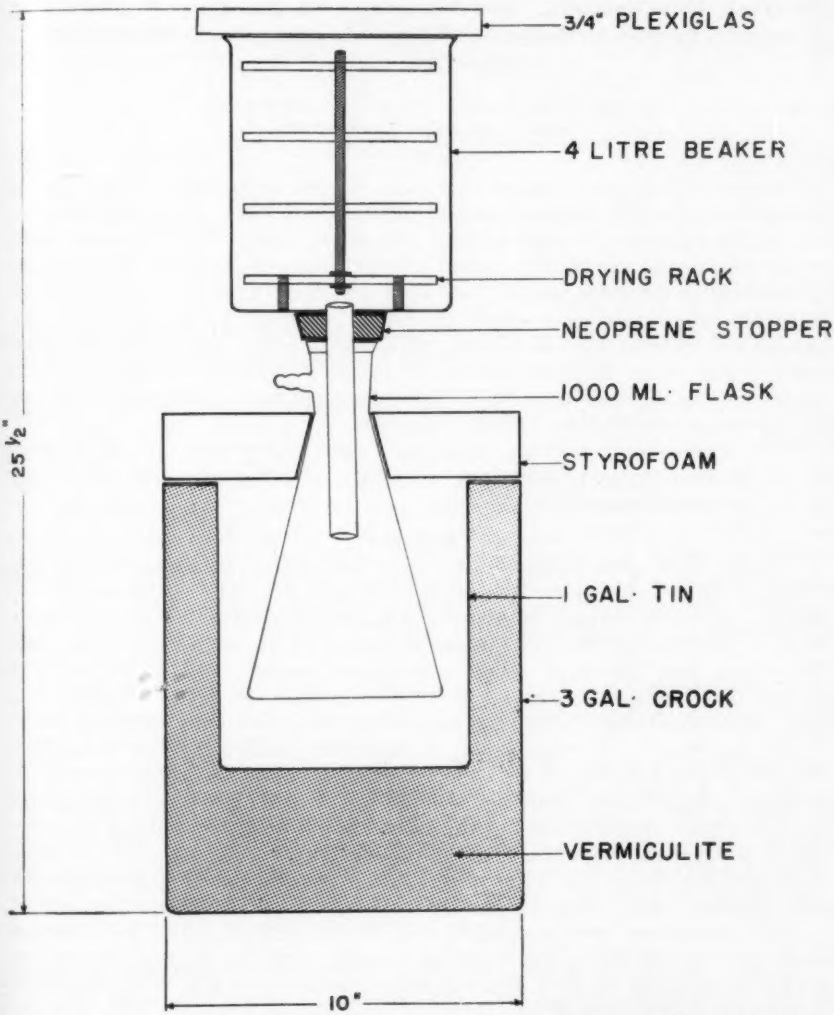

Fig. 1. Cross-section of the assembled drying chamber, moisture trap, and insulated bath.

sodium hydroxide vapour traps, to a high-vacuum pump. At room temperature dry ice is required only after 12 hours' operation and the apparatus dries as much as 100 gm. of fresh-frozen leaf material in 24 hours or less at a pressure of 20 microns of mercury. Loading and unloading the drying chamber, recovery of the condensate, and decontamination of the apparatus are simple operations.

Acknowledgments

The authors wish to thank Dr. A. J. McGinnis, Messrs. E. L. Longair, and A. G. Hewitt of the Entomology Section, Canada Agriculture Research Station, Lethbridge, Alberta, for suggestions and help in constructing the apparatus.

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Survival, Development, and Fecundity of the Pale Western Cutworm, *Agrotis orthogonia* Morr. (Lepidoptera: Noctuidae), After Starvation[1]

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Larvae of the pale western cutworm, *Agrotis orthogonia* Morr., may be starved in the field by planned control (Seamans and Rock, 1945) or elimination of their food supply as a result of their own depredation. Starvation may occur at any time during the feeding period. Some effects of starvation on mortality, particularly in the early instars, have been reported (Jacobson, 1952). Larvae that were fed only two hours each day had an additional instar, developed more slowly, and were smaller (McGinnis and Kasting, 1959). Starvation during the fourth instar when the larvae were fed on various foods resulted in smaller pupae, and the size and fecundity of females were directly associated with pupal size (Jacobson and Blakeley, 1958).

The investigations reported herein were made to test the effect of starvation on the mortality, development, and fecundity of half-grown and later stages of the pale western cutworm.

Methods

Larvae that were hatched from eggs laid in the laboratory by females collected in the field were reared by methods described by Jacobson and Blakeley (1957). Sprouts of Marquis wheat were used as food. The larvae were reared through the third instar in groups of 25 in 20- x 100-mm. petri dishes and, after the third moult, were placed singly in 15- x 60-mm. petri dishes. They were starved or fed until emergence or death. Starvation of third- and fourth-instar larvae was commenced two days after moulting and of fifth-instar larvae at intervals up to 11 days after moulting. The larvae were treated in two ways: by withholding food, first, until they died or until the survivors pupated or emerged and, second, for various periods after which they were fed again. Dates of each moult, commencement of the prepupal and pupal stages, emergence, and death were recorded. Pupae were weighed within 24 hours after pupation. No fewer than 50 larvae were subjected to any treatment, and a similar number were fed throughout their larval period as a control.

All experiments were conducted at a temperature of 25° C. in a constant temperature room where the variation was less than one degree. During the period of starvation the petri dishes containing larvae were held at approximately 50 per cent relative humidity.

Data collected on starved and unstarved larvae were analyzed by statistical methods described by Cox (1954).

Results

Effects of Starvation on Survival

When larvae were starved and then fed again, some of the survivors did not resume feeding and eventually died (Table I). The percentage mortality continued to increase after the end of the starvation period. Older larvae were able to survive longer periods of starvation. Mortality varied directly with the duration of the starvation period and inversely with the size of larvae.

When deprived of food larvae up to and including the fifth instar eventually died. When starvation commenced in the sixth (and seventh) instar there was

[1]Contribution from the Entomology Section.

TABLE I

Effect of various periods of starvation at 25°C. on larvae of the pale western cutworm

Instar	Days starved	Percentage mortality	
		At the end of starvation	Final
3rd	7	4	20
3rd	10	46	80
4th	10	16	42
4th	15	94	100
5th	15	56	90

some survival and the later the commencement of starvation the greater the number that pupated and emerged (Table II).

Effects of Starvation on Development

When third-, fourth-, and fifth-instar larvae were starved and not fed again, most of them moulted once but many of these died before moulting again. When fed after being starved, the survivors resumed development but the duration of the next instar was significantly longer (Table III). The prepupal period of larvae that had been starved was significantly shorter than those that were fed continuously. There was no significant difference in duration of the pupal period between starved and fed larvae. The total time from hatching to emergence was longer when feeding was interrupted by starvation than when feeding was continuous, but the period of increase was shorter than the starvation period.

Table IV shows that larvae starved at various intervals after the fifth moult emerged sooner than those that were fed. The data also show a similar trend in the duration of the pupal period.

Larvae may have more than six instars. In these experiments 22 per cent of the unstarved larvae had seven instars compared with 69 and 72 per cent of larvae that had been starved during the third and fourth instar, respectively. The duration of the larval stage was increased with supernumerary moults. The mean durations of the sixth and seventh instars were 8.0 and 5.6 days, respectively. Hence, the interval from the fifth moult to the prepupal stage was almost doubled by the extra moult.

Effects of Starvation on Weights of Pupae and Fecundity of Moths

The starving of larvae at various stages during their development had an effect on weights of pupae and fecundity of adults. Weights of pupae (mg.) and mean numbers of eggs per female of starved and unstarved larvae were:—

	Weight of pupae	No. of eggs
Not starved	421	390
Starved for ten days after third moult	370	126
Starved for three days after fifth moult	257	97
Starved for six days after fifth moult	106	88

When larvae were starved before the sixth instar and then fed again, the survivors resumed feeding and appeared to develop normally but the weights of the pupae were significantly smaller than those that were not starved.

TABLE II

Effect of starvation at 25°C. on last-stage larvae of the pale western cutworm

Days after moult	Percentage of original number		
	Larval mortality	Pupated	Emerged as adults
1	98	2	0
3	70	42	30
6	42	68	58

Discussion

Inadequate food supply, whether in quality or in quantity, is one of the hazards of survival in insects. This is true of many insect pests of crops where the source of food may be destroyed by crop rotation, cultural means, or feeding of the insect itself. All of these may be factors in the starvation of the pale western cutworm in the field.

When larvae are deprived of food the number of survivors is dependent upon the stage of development, the duration of the starving period (Jacobson, 1952), or the kind of crops they infest (Jacobson and Blakeley, 1958). The investigations reported herein have shown that the final larval mortality is greater than the mortality at the time that food is again made available. Apparently, many of the larvae are so weakened that they cannot resume feeding. For example, a mortality of approximately 50 per cent of third-instar larvae after 10 days' starvation resulted in a final mortality of 80 per cent (Table I). The eventual mortality in a severely infested field may be forecast if the stage of the larvae and the percentage mortality are known. Such knowledge can be helpful when reseeding a field that has been destroyed by *A. orthogonia.*

Supernumerary moults and a period of starvation prolonged the larval period of third-, fourth-, and fifth-instar larvae. Deprival of food after the fifth moult hastened pupation. Duration of the prepupal and pupal periods is associated with maximum larval weight and pupal weight, respectively, (Blakeley and Jacobson, 1960) and is, therefore, an indirect effect of starvation. The variation in the durations of the larval, prepupal, and pupal stages is not sufficient to warrant modification of recommended cultural practices concerning the reseeding of crops that have been destroyed by cutworms.

TABLE III

Mean durations (days) of various stages of the pale western cutworm when starved at 25°C. for various periods

Instar	Days starved	Instar				Prepupae	Pupae	Total*
		4	5	6	7			
3	7	10.4	4.5	5.3	6.4	7.8	25.2	71.6
4	10	3.2	16.0	5.1	6.4	7.8	24.5	75.1
5	10	3.2	6.5	12.4	6.0	7.2	23.5	70.7
–	0	3.2	6.0	5.7	3.5	10.9	25.7	67.0

*Includes 12 days, the durations of first three instars.

TABLE IV

Mean durations (days) at 25°C. from hatching to various stages of starved and unstarved larvae of the pale western cutworm

Treatment	To sixth instar	To pupa	To emergence
Starved three days after fifth moult....	21.4	47.5	69.8
Starved eight days after fifth moult....	21.7	47.6	70.6
Fed throughout......................	20.5	49.7	73.7*

*Difference between starved and unstarved significant at 1% level.

One of the most important effects of starvation was the reduction in adult fecundity. Starvation during the early instars caused little reduction in the pupal weights of the survivors. The greatest reduction in weights of pupae occurred when the larvae were deprived of food after the last moult. Lower fecundity as a result of reduced weights of pupae may be an important factors in reducing populations of cutworms. Heron (1955) found that the reproductive capacity of the larch sawfly, *Pristiphora erichsonii* (Htg.) was reduced by partial starvation of larvae. He also found that larvae in an outbreak area were 18 per cent lighter than those from another area where food was more plentiful.

In the field, larvae of the pale western cutworm may be partially or completely starved at various times and for various intervals during their feeding period, and as they are continuous feeders and development is relatively rapid, any interruption in feeding, except at the time of moulting, affects mortality, duration of the various stages, and fecundity of the females.

Summary

Larvae of the pale western cutworm, *Agrotis orthogonia* Morr., at different stages of development were starved at 25° C. for various intervals and compared with larvae that were fed continuously. Starvation during the first five instars resulted in mortality, prolongation of the larval period, occurrence of supernumerary moults, and lighter-weight pupae. Similar effects were obtained when larvae were starved in the ultimate instar except that mortality was reduced and there was a slight acceleration in larval development. Fecundity was reduced by starvation, as the pupae and the adults were smaller. Prolonged starvation caused mortality, the percentage of which was dependent on the size of larvae, and the final percentage mortality was greater than the mortality at the time when the larvae were allowed to resume feeding.

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A New Genus of Pyralidae and its Species (Lepidoptera)

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Coenostolopsis, new genus

Type species: *Coenostola* ? *apicalis* Lederer

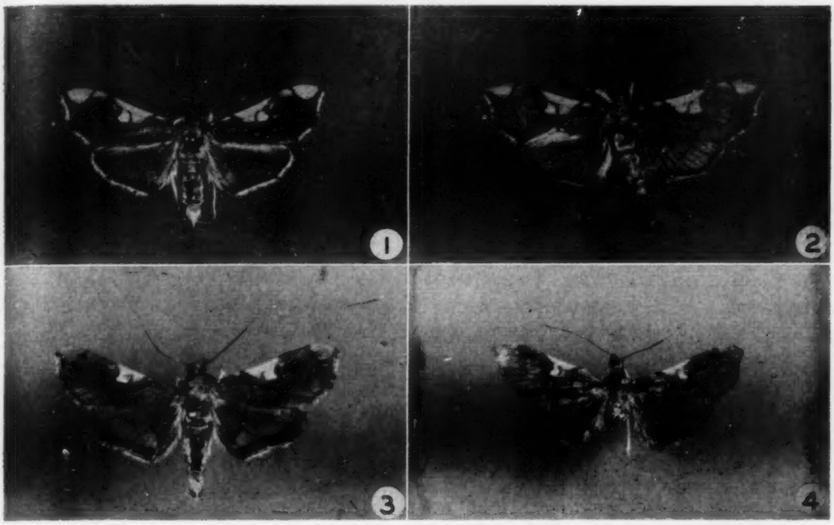
Frons somewhat flattened and oblique; labial palpus upturned, second joint with a deep, compressed carina of scales anteroventrally, third joint short and blunt, concealed in scaling of second; body moderately robust; praecinctorium prominently bilobed; anal tuft of male prominent. Forewing rather narrow, outer margin sinuate, apex acute; R_1 from before apex of cell; R_2 from apex, closely approximated to R_{3+4}; R_3 and R_4 stalked for about three-fifths of their length; R_5 straight and well-separated from R_{3+4}; M_1 from behind anterior angle of cell; discocellular weakly angulate; M_2, M_3 and Cu_1 arising fairly close together around posterior angle of cell; M_3 and Cu_1 weakly approximated basally; Cu_2 from cell rather close to angle; anal loop large and complete. Hind wing with outer margin weakly sinuated; Sc and R_s strongly anastomosed; R_s hardly stalked with M_1; cell short, discocellular weakly angled in middle; M_2, M_3 and Cu_1 from posterior angle of cell, approximated basally; Cu_2 from very close to angle of cell; three anal veins present.

Male genitalia. Uncus rather short, subtriangular, distally rounded, not prominently setose; subscaphium strong, straplike; vinculum prolonged into a short saccus; transtilla complete, ribbonlike; juxta small; coremata large and prominent; valve ear-shaped, with a prominent basal expansion of costa and with a hooklike clasper; penis cylindrical, with spinelike cornuti.

Female genitalia. Ovipositor small; apophyses slight; ductus bursae long, contorted and with sclerotized zones; bursa oval, membranous.

Key to the Species

1. Forewing above with a contrasting orange-yellow patch on costa just before apex .... *apicalis*
   Forewing above with at most some obscure yellowish suffusion before apex 2
2. Hyaline discal spot of forewing lunate; terminal area of hind wing above not infuscated .... *selenophora*
   Hyaline discal spot of forewing subquadrate; terminal area of hind wing above obviously infuscated .... *terminalis*



Figs. 1-4. *Coenostolopsis* spp. 1, 2, *C. apicalis* Lederer, ♂, ♀; 3, *C. terminalis* Munroe; 4, *C. selenophora* Hampson.

Coenostolopsis apicalis (Lederer), new combination

Figs. 1, 4, 7

Coenostola ? apicalis Lederer, 1863: 408, 479, Pl. 14, Fig. 16.
Phryganodes apicalis, Druce, 1895: 252.
Phostria apicalis, Klima, 1939: 137.

Head and palpi above and antenna fulvous; labial palpus beneath and under surface of head white; thorax and abdomen above warm brown; abdominal segments posteriorly margined with pale buff preceded by black; body beneath and legs whitish buff, shading to yellowish buff towards tip of abdomen. Forewing brownish fuscous; a yellow dash on costa before antemedial line; antemedial line fuscous, oblique outward to Cu, then erect and weakly sinuated to inner margin; medial area broadly yellow from costa to posterior margin of cell; a quadrate, pearly-hyaline spot in end of cell, bounded anteriorly and posteriorly with fuscous; a conspicuous yellow patch on costa before apex; postmedial line fuscous, beginning on subapical patch, oblique outward to cell R_5, then erect to Cu_2, strongly retracted to posterior angle of cell, then inwardly oblique to inner margin; fringe brownish fuscous, white-tipped except at medial lobe. Hind wing above brownish fuscous; a blackish fuscous discocellular bar; postmedial line blackish fuscous, erect to Cu_2, then retracted to Cu_2 and nearly straight to inner margin; a narrow terminal zone of slightly warmer-brown scales; fringe dark fuscous in basal half, distal half white except narrowly at median lobe and anal angle. Wings beneath greyish fuscous; both wings with obscure, dotted postmedial line; forewing with hyaline spot as above; hind wing with slender fuscous discocellular lunule; both wings with narrow, fuscous, terminal line; fringes as above. Expanse 23 to 26 mm.

Male genitalia. Uncus rather broad, its lateral margins angulate in middle; valve not very long; clasper long and curved, exceeding dorsal margin when in dorsal position; vinculum triangular; penis with an anterior series of four larger cornuti, followed by a posterior series of four smaller ones.

Female genitalia. Ovipositor small; apophyses small and weakly sclerotized; ductus bursae long, narrow near ostium and with a small, sclerotized collar, then contorted and greatly expanded, with a funnel-shaped sclerotization, then again narrowed, elongated and scobinated; bursa elongate, membranous, finely spinulose.

Types. One male, one female, syntypes, in Vienna Museum and Kaden Collection, Leningrad. I select the male in the Vienna Museum as lectotype.

Range. Guatemala to Bolivia and southern Brazil.

Material examined. 23 specimens from:—*Guatemala*: Cayuga; *Venezuela*: Las Quiguas, San Esteban Valley; *British Guiana*: Bartica; *Brazil*: Hyutanahan, Rio Purus; Rio de Janeiro; Corupá, Sta. Catharina; *Bolivia*: Prov. del Sara, 450 m.; Buenavista, 400 m.; San Antonio, Chapare, Cochabamba, 400 m.

Coenostolopsis terminalis, new species

Figs. 2, 5

Head above, antenna, palpi above, and base of proboscis fulvous brown; base of labial palpus beneath and under side of head white; thorax above brownish fuscous; abdomen above greyish or brownish fuscous, posterior margins of segments narrowly whitish buff, preceded by black; terminal segment fulvous; anal tuft buff; body beneath and legs whitish buff, abdomen darker posteriorly. Forewing brownish fuscous, a yellow bar before antemedial line on costa; antemedial line dark fuscous, oblique outward to Cu, then erect to inner margin; medial area orange-yellow from costa to posterior angle of cell; a subquadrate hyaline patch in end of cell, preceded and followed by a fuscous line; postmedial line dark fuscous, oblique outward to R_5, then slightly inwardly oblique to Cu_2, there retracted basad towards, but not to, posterior angle of cell, then inwardly oblique to margin; outer margin narrowly infuscated; fringe dark brown, distal half pale creamy buff behind apex and behind median lobe. Hind wing dark brownish fuscous; a dark-fuscous discocellular bar; postmedial line dark fuscous, straight and oblique from near costa to Cu_2, there retracted to behind angle of cell, then straight to anal margin; termen broadly infuscated; fringe dark in basal half, distal half dark anteriorly, pale yellowish buff behind median lobe. Wings beneath greyish fuscous; postmedial lines faintly indicated as rows of dots; hyaline spot of forewing as above; a narrow discocellular lunule on hind wing; fringe as above but somewhat paler. Expanse 25 to 31 mm.

Male genitalia. Uncus regularly triangular, rather small and narrow, margins straight, not angulate; valve much as in *apicalis;* vinculum narrowly triangular, penis with about 13 small cornuti in a straight series.

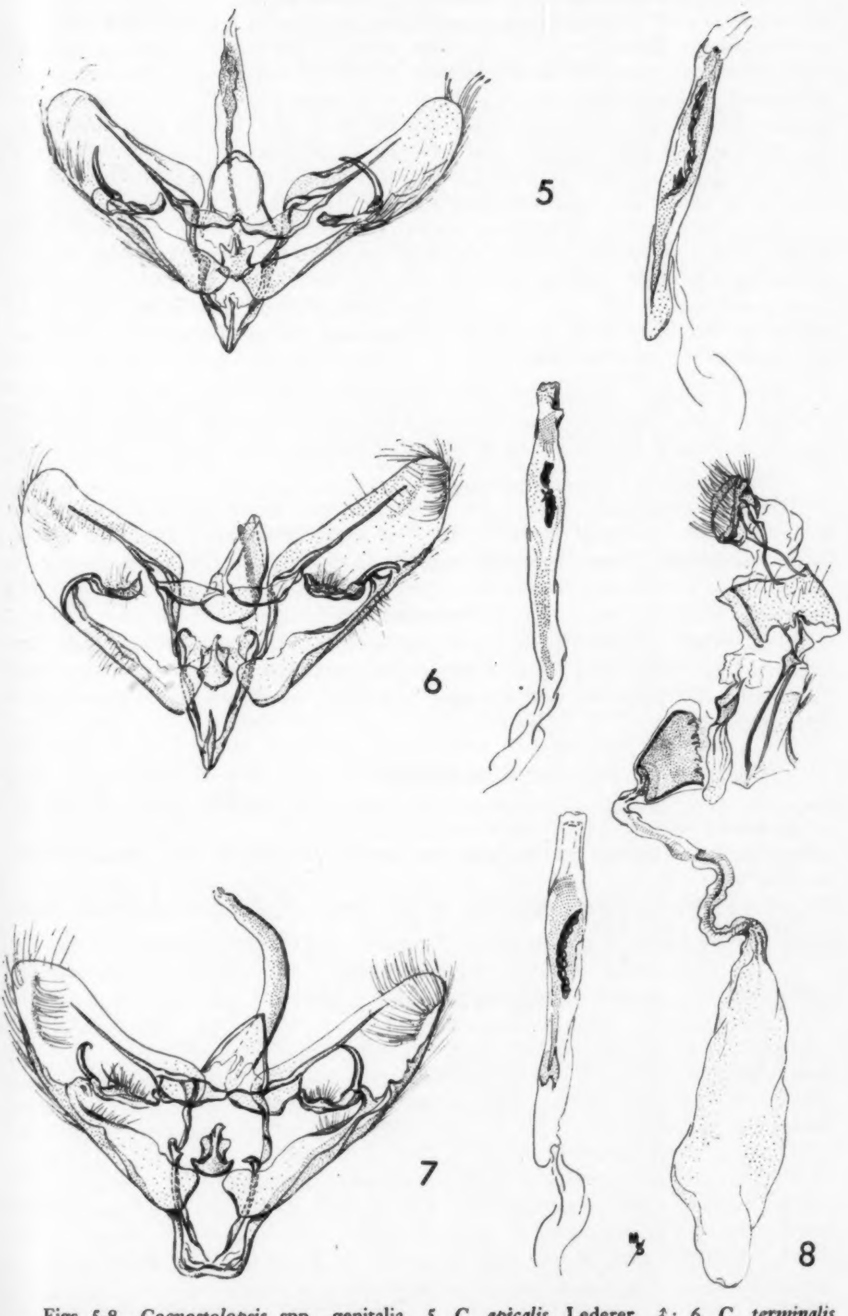
Holotype, male, Rio Yapacani, E. Bolivia, 600 m., J. Steinbach; eight male paratypes from:—*Bolivia*: Rio Yapacani, 600 m.; Prov. del Sara, 400 m.; Sta. Cruz de la Sierra, 450 m.; *Peru*: Chanchamayo (Thamm). Paratypes in the Carnegie Museum, the Berlin Museum, and the C.N.C. Carnegie Museum type lot No. 127; C.N.C. type No. 6922.

Coenostolopsis selenophora (Hampson), new combination

Figs. 3, 6

Phryganodes selenophora, Hempson, 1912: 332.
Phostria selenophera [sic], Klima, 1939: 137.

Head and palpi brown; antenna fuscous; thorax and abdomen above purplish fuscous, with some greyish-buff scales; anal tuft buff; thorax beneath and legs light greyish buff; abdomen beneath purplish fuscous. Forewing above dark



Figs. 5-8. *Coenostolopsis* spp., genitalia. 5, *C. apicalis,* Lederer, ♂; 6, *C. terminalis* Munroe, ♂; 7, *C. selenophora* Hampson, ♂; 8, *C. apicalis* Lederer, ♀.

greyish fuscous; a small orange-yellow spot on costa just beyond base; an orange-yellow costal dash just before antemedial line; antemedial line dark fuscous, outwardly oblique from costa to cell, then erect to posterior margin; a narrow trapezoidal orange-yellow area, broadest on costa, extending from antemedial line to end of discocellular lunule and a short distance into cell; a hyaline, lunular spot on discocellulars; a broad, darker-fuscous shade just beyond cell; postmedial line obscure, dark-fuscous, erect and crenulated from costa to Cu_2, then retracted about two-thirds of the way to cell, then more or less erect to posterior margin. Hind wing above dark greyish fuscous, a dark-fuscous discocellular bar; postmedial line dark fuscous, erect from costa to Cu_2, then retracted to posterior angle of cell, thence proceeding in a line with discocellular bar to anal margin. Under surface light purplish fuscous; forewing without antemedial line and with yellow costal patch hardly indicated; discocellular lunule present; hind wing with discocellular bar hardly evident; postmedial line on both wings as above but narrower and broken. Expanse 29 mm.

Male genitalia. Uncus triangular, rather broad, lateral margins not angulate in middle; valve a little longer and clasper a little shorter than in *apicalis;* vinculum broader and more rounded than in the other species; penis with a curved series of about 11 large cornuti.

Material examined. The type, from Jiminez, western Colombia, in the British Museum (Natural History) and one male from Santo Domingo de los Colorados, 650 m., Prov. Pichincha, western Ecuador, coll. J. Foerster.

Summary

Coenostola apicalis Lederer and *Phryganodes selenophora* Hampson are removed from *Phostria* to the new genus *Coenostolopsis*, type species *C. apicalis.* The species are reviewed and the new species *C. terminalis*, from Bolivia and Peru, is described.

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New Nearctic Species of the Genus *Pristiphora* Latreille (Hymenoptera: Tenthredinidae)[1]

By H. R. Wong[2] and H. H. Ross[3]

Since the last revision of the genus *Pristiphora* Latreille by Marlatt (1896), several new species of this genus have come to the attention of the authors. The following descriptions of these are essential to the development of other studies concerning the biology of individual species, and a study of the evolution of the genus by the senior author.

The characteristics of the genus *Pristiphora* are outlined by Ross (1937) and Benson (1948). The terminology of the genitalic structures of the male and female is that proposed by Ross (1945).

We wish to express our appreciation to: Dr. B. D. Burks, United States Department of Agriculture, Entomology Research Division, Washington, D.C., for the loan of several specimens; personnel of the Canadian Forest Insect Survey for the collection of several new species; R. B. Benson, British Museum (Natural History), London, and E. Lindqvist, Helsingfors-Munksnas, for examples of many European species of *Pristiphora,* which were compared with the Nearctic species; and J. A. Drouin for assisting in the preparation of the illustrations.

Pristiphora leechi, new species

Female.–Length 7 mm. Head, venter and legs mainly yellowish. The following parts black: antennae, eyes, large patch on vertex extending cephalad to lateral margin of antennal sockets and caudally to occiput, postgenae, cervical sclerites, dorsum of thorax and abdomen, epimera of mesothorax, pleura of metathorax, sheath, basal area of coxae, lateroventral area of abdomen, inner margin of femora, apex of tibiae and tarsi. Sheath pointed in lateral view (Fig. 15). Tarsal claws with a minute subtooth. Scopa triangular and shallow. Lance of saw (Fig. 9) with radix expanded and tapered to a pointed lamnium. Lancet (Fig. 10) dagger-like with radix longer than lamnium; wide ctenidia present on sutures 1 to 7 of lamnium.

Male.–Length 6 mm. Colour closely resembles that of female. Penis valve (Fig. 18) with a short, sharply pointed valvispina, and a narrowed pseudoceps.

Holotype female.–Christina Lake, British Columbia; June 25, 1951; reared from *Larix occidentalis* Nutt.; No. 51-468A (Canadian National Collection).

Allotype male.–Grand Forks, British Columbia; July 11, 1951; reared from *Larix occidentalis* Nutt.; No. 51-550 (Canadian National Collection).

Paratypes.–British Columbia: 1 ♂, 1 ♀; Elko; July 4-August 9, 1951; No. 51-454 and No. 51-1618A. 2 ♂, 1 ♀; Inonoaklin; July 10-13, 1953; No. 53-764-02. 1 ♀; Beaver Creek; July 23, 1953; No. 53-924-04. 2 ♂; Winlaw; July 13-17, 1953; No. 53-631-01, No. 63-631-02. 1 ♀; New Denver; incubated January 1, 1952; No. 51-3090. 1 ♂; Kettle Valley; July 4, 1951; No. 51-163. 1 ♀; Natal; incubated January 26, 1952; No. 51-3015. 1 ♂; Burton; incubated January 30, 1952; No. 51-3280A. 1 ♂; Cana Flats; incubated January 29, 1952; No. 51-3146. 1 ♀; Whitetail Lake Road; July 31, 1951; No. 51-1741. 1 ♀; Greenwood; June 27, 1951; No. 51-353. Washington: 1 ♀; Pullman; June, 1921. Idaho: 1 ♀; Lake Waha; June 9, 1918; A. L. Melander. 1 ♂; Hope; April 27, 1958; Hopk. U.S. 20340; R. E. Denton. 1 ♀; Bovill; June 17, 1958; Hopk.

[1]Contribution No. 596, Research Branch, Forest Biology Division, Department of Agriculture, Ottawa; and Illinois Natural History Survey, Urbana, Illinois.
[2]Forest Biology Laboratory, Winnipeg, Manitoba.
[3]Illinois Natural History Survey, Urbana, Illinois.

U.S. 20354; R. E. Denton. MONTANA: 2 ♀; Bonner; June 4-16, 1958; Hopk. U.S. 20353 and 20339; R. E. Denton.

All paratypes from British Columbia and those collected by R. E. Denton were reared from *Larix occidentalis* Nutt. The paratypes are deposited in the Illinois Natural History Survey Collection, the United States National Museum, the Canadian National Collection, and the Winnipeg Insect Survey Collection.

P. erichsonii (Htg.) and *P. leechi* are the only species of *Pristiphora* recorded as feeding on larch in North America. These two species can be readily separated by the colour of the abdomen. That of *erichsonii* is black with a broad red band, while that of *leechi* is black dorsally and yellow ventrally. The latter species is separated from all other species in the same genus by the shape of the penis valve of the male, and the lance and lancet of the female.

Pristiphora hucksena, new species

Female.–Length 7 mm. Colour black with legs brownish-orange except for basal part of coxae, apex of tibiae and tarsi of posterior legs. Sheath (Fig. 16) has a short truncated apical margin. Scopa thin and higher than the distance between it and the inner margin of the sheath. Mesopleura dull and rough. Tarsal claws with a minute subtooth. Lance of saw (Fig. 5) broad and moderately tapered. Lancet (Fig. 6) with a broad tangium, and a well developed tangial process on the dorsal margin; lamnium with thin ctenidia on sutures 3 to 16.

Holotype female.–Vancouver, British Columbia; April 23, 1931; H. H. Ross (Illinois Natural History Survey Collection). Paratype female.–Same data (Canadian National Collection).

This species resembles *sycophanta* Walsh, but the latter lacks the brownish-orange coloration of the legs and prominence of the tangial process on the lancet.

Pristiphora elaphita, new species

Female.–Length 6.5 mm. Colour black with cerci and the following parts of the legs light yellowish-brown: apex of coxae; trochanters; apical area of femora (darker), tibiae and tarsi of the two anterior pairs; basal two-thirds of the posterior tibiae. Sheath as in Fig. 16. Scopa broad and shallow. Mesopleura dull and rough. Tarsal claws with a minute subtooth. Lance of saw as in Fig. 5. Lancet (Fig. 13) possessing a broad tangium with a moderate tangial process at the dorsoanterior edge; lamnium with thin ctenidia on sutures 2 to 14.

Holotype female.–Glaslyn, Saskatchewan; June 28, 1952; Forest Insect Survey Winnipeg 1367 (Canadian National Collection).

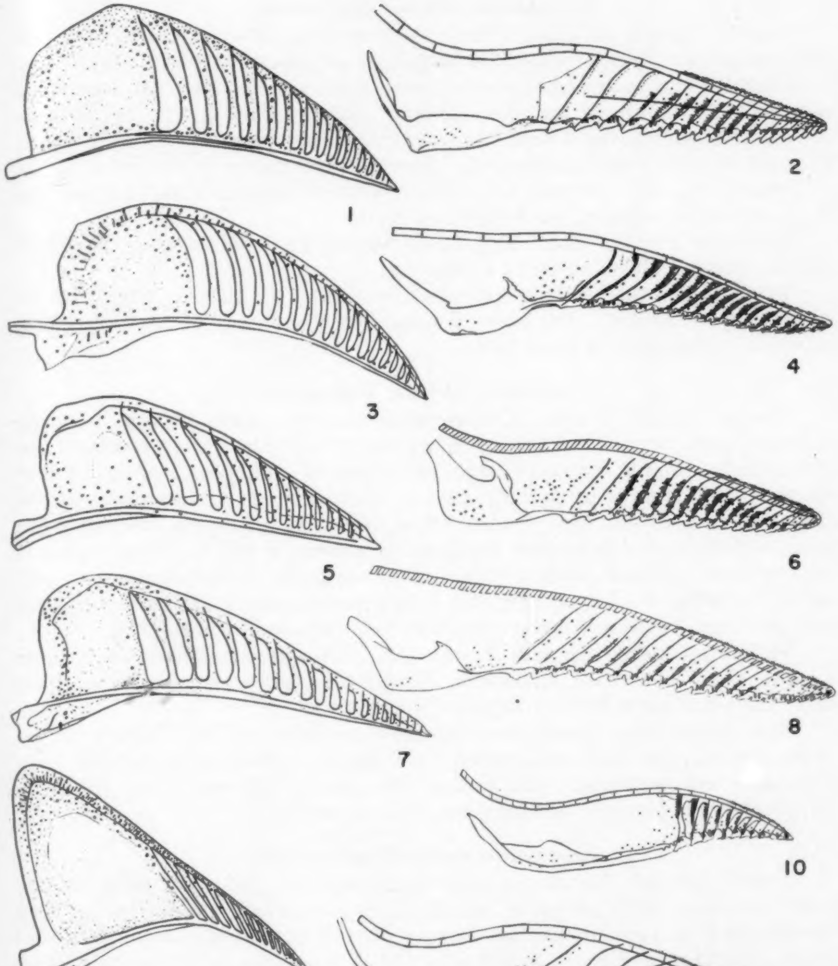
This species is closely related to *hucksena* W. & R. The smaller tangial process and thin ctenidia on the second suture of the lancet of *elaphita* will separate it from *hucksena.*

Pristiphora valvangula, new species

Male.–Length 5.5 mm. Colour black with the following parts of the legs pale yellowish-brown: distal area of femora, tibiae and tarsi of the two anterior pairs; trochanters and basal area of the tibiae of the posterior pair. Tarsal claws with a minute subtooth. Penis valve (Fig. 19) with a sharply curved and tapered paravalva; pseudoceps with a slanted apical margin; basal end of valvura club-like.

Holotype male.–No location cited; H. Yuasa; July, 1918; 155-4-1. (Illinois Natural History Survey Collection). Yuasa (1922) indicated that the greater part of his collection was made during the summer of 1917-1918 at Ithaca, New York. The probable locality of this specimen is Ithaca, New York.

This species is closely related to *sycophanta* Walsh. The new species has a more slender and curved paravalva than *sycophanta.*



Figs. 1-13. Saws of *Pristiphora.* 1, lance of *cadma;* 2, lancet of *cadma;* 3, lance of *venatta;* 4, lancet of *venatta;* 5, lance of *hucksena;* 6, lancet of *hucksena;* 7, lance of *aphanta;* 8, lancet of *aphanta;* 9, lance of *leechi;* 10, lancet of *leechi;* 11, lancet of *paloma;* 12, lancet of *serrula;* 13, lancet of *elaphita.*

Pristiphora paloma, new species

Female.—Length 7.5 mm. Colour black with the following parts whitish or yellowish-brown: tegulae; posterior margin of prothorax; clypeus; labrum; base of mandibles; legs except basal part of coxae, femora of mesothoracic legs, apical half of tibiae and tarsi of metathoracic legs. Sheath as in Fig. 16. Scopa broad and about as wide as the distance between it and the inner margin of the sheath. Tarsal claws with a distinct subtooth. Lance of saw narrowly tapered as in Fig. 7. Lancet (Fig. 11) with narrow tangium, without ctenidia on sutures, but with the apical serrula distinct and having two teeth.

Holotype female.—Antioch, Illinois; August 24, 1935; Delong and Ross (Illinois Natural History Survey Collection).

In the key to the Nearctic species of *Pristiphora* by Marlatt (1896), *paloma* runs to *banksi* Marlatt. The larger size and lighter coloured prothoracic legs of *paloma* will distinguish it from *banksi*.

Pristiphora serrula, new species

Female.—Length 8 mm. Colour predominantly reddish-orange with the following parts black: head (except apical area of clypeus, labrum and basal part of mandibles); ninth and tenth terga; cerci; ventral and apical margins of sawsheath; thorax (except pronotum); base of coxae; apex of femora, basal part of tibiae and tarsi of hind legs. Sawsheath as in Fig. 16. Scopa is narrow, longer than cercus but not higher than the distance between it and the inner margin of the sawsheath. Tarsal claws with a distinct subtooth. Lance of saw narrowly tapered as in Fig. 7. Lancet (Fig. 12) with a narrow tangium and a slight tangial process at the dorsoanterior edge; lamnium without ctenidia on sutures.

Holotype female.—Carrville Trinity Co., California; Alt. 2400-2500 ft.; June 1, 1934; E. C. Van Dyke (California Academy of Sciences). Paratype.—Same data (Illinois Natural History Survey Collection).

The coloration of *serrula* resembles *quercus* (Htg.). The Nearctic species *idiota* (Nort.) has been synonymized by Benson (1958) with *quercus*. The larger size and the distinct gap between the apex of the lancet and the apical serrula of the new species will separate it from *quercus*.

Pristiphora aphanta, new species

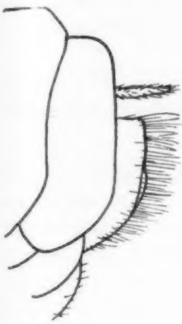
Female.—Length 7.5 mm. Colour black with the following parts reddish-brown to white: apical margin of labrum; tegulae; trochanters; apical half of front femora; tibiae and tarsi of the two anterior pairs of legs; basal two-thirds of hind tibiae. Sawsheath (Fig. 17) simple with a small thin scopa, which is shorter than cercus, located on the dorsoapical corner. Tarsal claws with a distinct subtooth. Lance of saw (Fig. 7) narrowly tapered. Lancet (Fig. 8) with a narrow tangium and a broad tangial process; lamnium with thin ctenidia on sutures 4 to 14.

Holotype female.—Labrador Lake, Cortland County, New York; June 16, 1937; D. T. Ries and M. E. Davis (Illinois Natural History Survey Collection).

The small simple sawsheath of *aphanta* resembles that of *winnipeg* Nort. The former species can be distinguished by the smooth shining mesopleura and short dorsoapical scopa.

Pristiphora venatta, new species

Female.—Length 8 mm. Colour black with the following parts pale reddish-brown: tegulae; dorsum of prothorax; labrum; legs except for coxae, inner margin of femora, and apex of tibiae and tarsi of the posterior pair. Clypeus emarginate. Ventral margin of sawsheath rounded. Scopa narrow and longer



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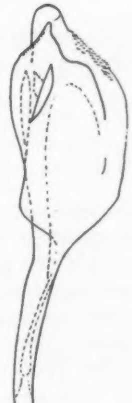

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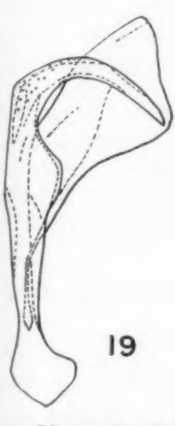

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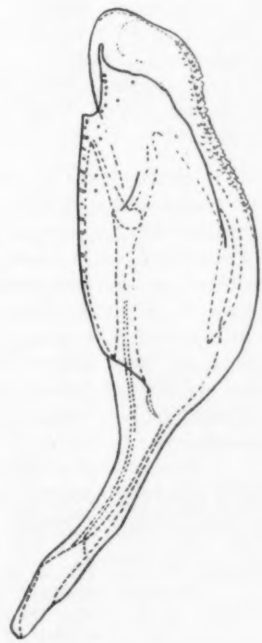

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Figs. 14-17. Sawsheaths of *Pristiphora*. 14, *cadma;* 15, *leechi;* 16, *hucksena;* 17, *aphanta.* Figs. 18-20. Penis valves of *Pristiphora*. 18, *leechi;* 19, *valvangula;* 20, *parbeta.*

than cercus. Tarsal claws with a distinct subtooth. Lance of saw (Fig. 3) broadly tapered with dorsal margin rounded. Lancet (Fig. 4) with narrow tangium and a slight tangial process; lamnium with thin ctenidia on sutures 2 to 16.

Holotype female.—Vollmer, Idaho; (Illinois Natural History Survey Collection).

The lancet of *venatta* resembles that of *bivittata* (Nort.). The species *venatta* is predominantly black in colour, and has a tangial process on the lancet.

Pristiphora cadma, new species

Female.—Length 8 mm. General colour orange with the following parts black: large patch on vertex, most of dorsum of thorax, most of the mediodorsal area of abdomen, epimera of mesothorax, pleura of metathorax, apex of tibiae, and tarsi of posterior legs. Light brown to brownish antennae, clypeus, labrum, frons, orbits of the eyes, longitudinal patch on each side of the scutum, basal area of scutellum, cerci, and ventral and apical margins of sawsheath. Clypeus emarginate. Tarsal claws with a distinct subtooth. Sawsheath (Fig. 14) broad with inner margin reflexed to form a distinct carina. Scopa low and rounded, longer than cercus. Lance of saw (Fig. 1) with the dorsal margin angulate. Lancet (Fig. 2) with a narrow tangium; lamnium with apex truncate and thin ctenidia on sutures 4 to 13.

Holotype female.—Meadow Lake, Saskatchewan; Forest Insect Survey Winnipeg 46 W875D; adult collected from *Betula papyrifera* Marsh. (Canadian National Collection).

The pale venter, black dorsum and black patch on the vertex of *cadma* resemble *leechi* W. & R. The species *cadma* is readily separated by its larger size, and by having a low rounded scopa.

Pristiphora parbeta, new species

Male.—Length 6.5 mm. Colour black with the following parts yellowish-brown: tegulae, dorsum of prothorax, labrum, apex of coxae, trochanters, tibiae and tarsi of the two anterior pairs of legs, and the basal four-fifths of the posterior tibiae. Apical margin of clypeus and upper posterior orbits of the eyes reddish-brown. Clypeus emarginate. Tarsal claws with a minute subtooth. Mesopleura dull and rough. Penis valve (Fig. 20) curved with a distinct notch between paravalva and valvispina.

Holotype male.—Onanole, Manitoba; larva reared from *Betula papyrifera* Marsh.; Forest Insect Survey Winnipeg 51 W1316B (Canadian National Collection).

This species resembles the Palaearctic species *alpestris* (Konow), but the dull and rough mesopleura of *parbeta* will separate it from *alpestris* in which the mesopleura are shining.

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Outbreaks of the Forest Tent Caterpillar, *Malacosoma disstria* Hbn., and Their Effects on Stands of Trembling Aspen in Manitoba and Saskatchewan[1]

By V. Hildahl[2] and W. A. Reeks[2]

Introduction

Stands of trembling aspen in Manitoba and Saskatchewan are frequently attacked by the forest tent caterpillar, *Malacosoma disstria* Hbn. The recent history of attack is reviewed in this paper to determine if there is evidence of a consistent pattern of outbreaks and if the latest of these had any appreciable effect on aspen stands in the two provinces.

The terms "infestation" and "outbreak", as used in this discussion, require some explanation. The term "infestation" refers to the occurrence of the insect on host trees in a stand or area in any specific year. The term "outbreak" refers to two or more successive severe infestations that appear to have a common epicentre or genetic origin, with the earliest and latest infestations of an outbreak not necessarily occurring within the same stand. The definition of the latter term is slightly broader than that given by Graham (Graham, 1952) in his definition of "Periodic Outbreak". The broader definition is necessary to cover the common situation wherein populations decline much sooner at the epicentre than at the periphery or front of the outbreak. Unfortunately the epicentre or origin of an outbreak cannot always be demonstrated. Infestations in discontinuous stands over a large region may represent a single large outbreak or a number of small outbreaks, so in cartographical representations of infestations the epicentres often have to be assumed.

A review of the early literature shows that the history of outbreaks is not as well known in the Prairie Provinces as in the eastern or western provinces of Canada or the central states of the U.S.A. It is only from about 1923 onward that records of infestations have been of a continuing nature. Until recently we failed to adopt a standard measurement of infestations, but from 1937 most of the surveys have been based on visual estimates of defoliation from the ground and aerial surveys of defoliated aspen stands. Three broad classes of infestations are now based on defoliation estimates, as follows: Light — trace to 20 per cent; moderate — 30 to 60 per cent; and severe — 70 to 100 per cent. Defoliation that can be observed from the air at about 1,000 feet generally falls within the moderate or severe classification of ground surveys. Defoliation estimates on mortality plots are expressed as percentages of foliage destroyed.

Although the forest tent caterpillar feeds on many species of deciduous trees and shrubs (Hodson, 1941), we are mainly concerned with its effect on aspen in pure stands or mixed with white spruce.

History of Infestations and Outbreaks

Infestations

Because of the inadequacy of reporting, most of the early observations on the occurrence of the forest tent caterpillar must be regarded as incomplete records of infestations rather than outbreaks. An early report (Baird, 1917) states that the insect was in great abundance all over Canada in 1887. This seems to be the first although indirect reference to the insect in Manitoba and Saskat-

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chewan. Nothing apparently is known about the insect in this region from 1887 to 1909, nor were any infestations reported in central Canada from 1910 to 1915 (Baird, 1917). The insect was not generally abundant in the United States or Canada from 1914 to 1918 (Hodson, 1941). By examining the records in the annual reports of the Insect Pest Review, the Entomological Society of Ontario, and the files of the Forest Insect Survey, it is possible to reconstruct the infestation history of the insect from 1923. Except for the well documented infestations of 1924 (de Gryse, 1925), the accompanying infestation maps (Figs. 1, 2) for the period 1923 to 1936 must be considered as approximate, and allowances should be made for large agricultural areas that fall within the infestation boundaries. This is particularly true for the infestations shown in the grassland belt, where aspen stands are largely confined to the river valleys, coulees, and the northern exposure of the southern hills. Also, the infestation maps for this period cover only areas where observers indicated that the defoliation was severe, often resulting in complete defoliation of aspen stands. No definite records of infestations could be found for the years 1931 and 1935. However, records for the succeeding years, 1932 and 1936, indicated continuation of attack, so the few gaps in the records undoubtedly were incurred by failure to report active infestations.

Records from 1937 (Fig. 2) are reasonably accurate, but the boundaries of infestations could not always be precisely defined, and it is probable that some spot infestations were overlooked.

It is clear that infestations of severe intensity have occurred in some part of Manitoba and Saskatchewan almost every year from 1922 to 1953. Most of the infestations declined in 1953 and 1954 (Blais *et al.*, 1955, Prentice, 1954) and by 1954 the only stands showing measurable defoliation were in the vicinity of Meadow Lake, Saskatchewan. No traces of defoliation could be detected in either province in 1955 and 1956. In 1957 only very light defoliation was observed and this was confined to the Cypress Hills. Complete defoliation of aspen occurred over a large part of the Cypress Hills Provincial Forest in 1958. Moderate defoliation was also noted in the Prince Albert and Hudson's Bay districts of Saskatchewan in 1958, but part of the defoliation was attributed to the large aspen tortrix, *Choristoneura conflictana* (Wlk.).

Outbreaks

The question arises as to whether the history of infestations in the two provinces shows recognizable outbreaks. An inspection of Figures 1 and 2 suggests at least four sequences of infestations, representing a complexity of outbreaks.

The first sequence of infestations appeared to originate in the Moose Mountain area of Saskatchewan about 1922, extending as far west as Edmonton, Alberta, by 1924 (de Gryse, 1925). From Edmonton the infestations followed a path into northwestern Saskatchewan, extending through Lloydminster, Battleford, and Prince Albert. The "path" gradually extended to the Saskatchewan-Manitoba boundary, spreading southeasterly and finally easterly, terminating in southeastern Manitoba about 1949. This 28-year history of infestations appears to constitute a single outbreak, but because outbreaks of this duration are unknown, it must be assumed that this sequence represents several inseparable outbreaks. These were independent of outbreaks in the adjacent state of Minnesota, where aspen stands were free from tent caterpillar attack from 1939 to 1947 inclusive (Duncan and Hodson, 1958).

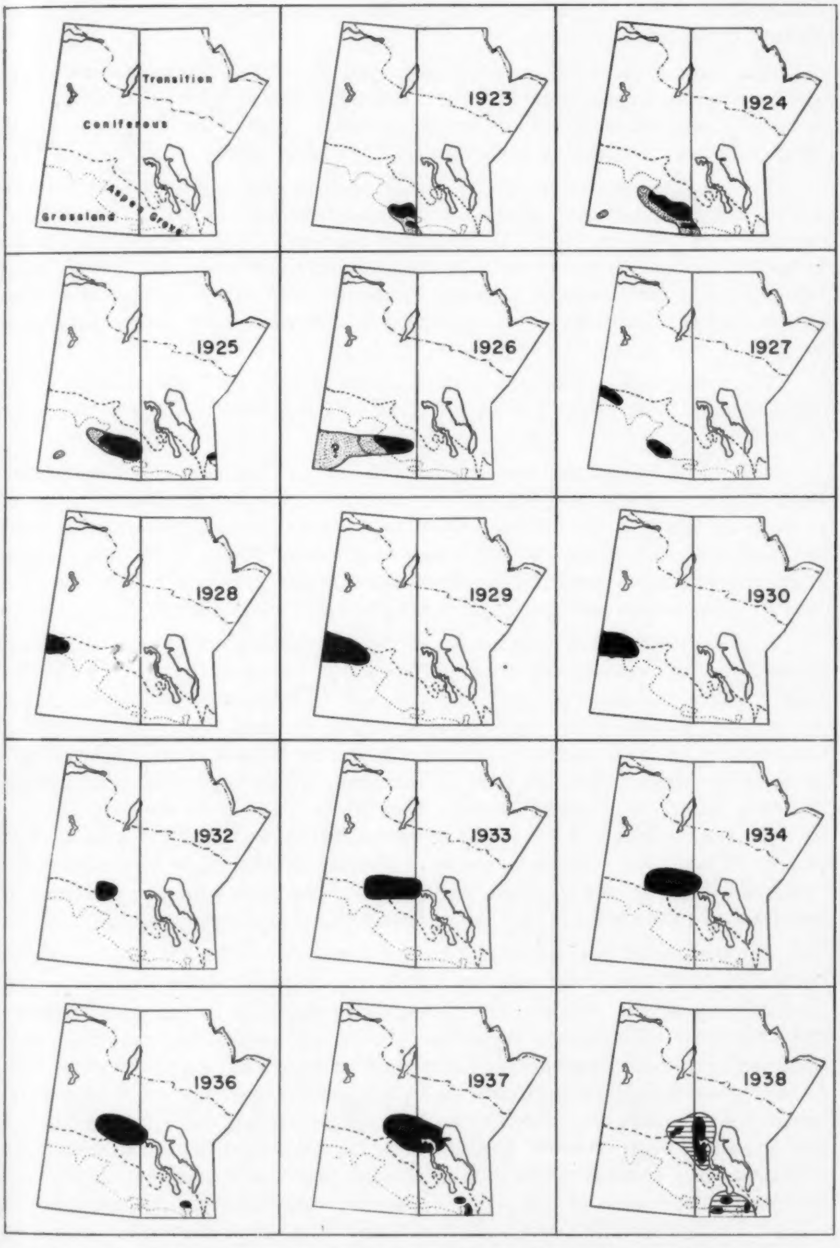

Fig. 1. Infestations of the forest tent caterpillar in Manitoba and Saskatchewan from 1923 to 1938. Stippling denotes grassland region with scattered stands of defoliated aspen. Hatching denotes light defoliation of aspen. Solid black denotes moderate to severe defoliation of aspen.

The second sequence of infestations started as a small focal point in southern Manitoba in 1936. By 1938 it merged with infestations reported from North Dakota, collapsing in 1939.

The third sequence of infestations started in 1950 in central Saskatchewan. Two epicentres were apparent in 1951, and these converged in 1952 (Fig. 2) to form what may be regarded as a single outbreak. This extended almost equally in all directions, eventually collapsing in 1954 after severe defoliation in 1953.

The fourth sequence of infestations appeared to originate in Ontario (Sippell, 1957), and extended into Minnesota where defoliation reached its greatest intensity from 1951 to 1953 (Duncan and Hodson, 1958). Similar conditions extended westerly from Ontario into Manitoba about 1949 and 1950. These infestations in northwestern Ontario, Minnesota, and Manitoba appear to constitute a single outbreak, which collapsed in Manitoba after severe defoliation in 1953.

The upsurge of populations in the Cypress Hills in 1957, followed by severe defoliation in 1958, marks the beginning of a new outbreak that was still active in 1959.

It should be noted that some years over the past three decades were characterized by widely separated infestations that may represent independent outbreaks or parts of larger ones. In the case of more easily recognized outbreaks, their paths of extension moved through various kinds of forest conditions, ranging from uncommercial, scattered stands of aspen in the grassland belt to stands of varying composition and age in the aspen grove and mixed forests.

Sippell (1957) noted that stands over large areas in Ontario were commonly infested for four consecutive years and generally were free from attack the fifth year. Much the same pattern was apparent in Manitoba and Saskatchewan during the 'forties, when aspen stands usually showed one year of light to moderate attack, two years of severe attack, and finally one year of light or light to moderate attack. The duration of outbreaks within individual stands during the early 'fifties was slightly shorter, observations on 14 plots showing one year of light attack, followed by a year of severe attack, and finally a year of light attack. Three plots were moderately to severely defoliated for two consecutive years, followed by one year of light attack. Nine plots near the periphery of the outbreaks were only lightly infested for three consecutive years.

The periodicity of outbreaks of the forest tent caterpillar has been recognized by Baird (1917) and other authors, but it is questionable as to how periodicity should be measured. Sippell (1957) expressed periodicity as the period between the first years of outbreak, regardless of whether or not the outbreaks were common to specific locations. This method of determining periodicity is satisfactory when individual outbreaks are clearly recognizable, but is not satisfactory under prairie conditions where outbreaks tend to overlap. For this reason it is perhaps advisable to consider periodicity as the time lapse from the first severe infestation at a location to the first infestation of the next outbreak at the same location. Application of this procedure to the records for ten selected locations (Table I) suggests that periodicity may range from about six to 16 years, with an average of 10 years. However, these figures do not take into account the fact that four of the locations fell within the paths of outbreaks only once during the 35-year period. There is nothing to indicate that outbreaks are cyclic.

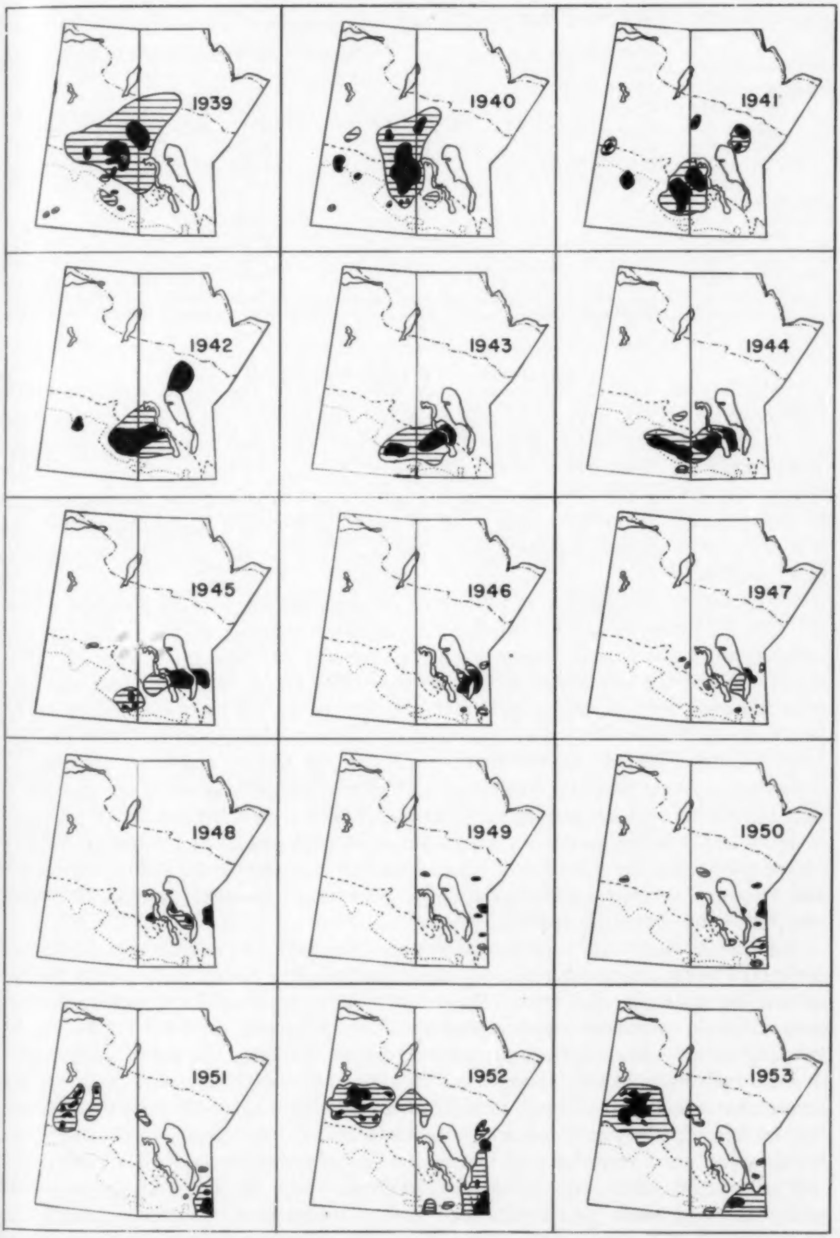

Fig. 2. Infestations of the forest tent caterpillar in Manitoba and Saskatchewan from 1939 to 1953. Hatching denotes light defoliation of aspen. Solid black denotes moderate to severe defoliation of aspen.

TABLE I.
"Periodicity" of Outbreaks of the Forest Tent Caterpillar at Ten Locations in Manitoba and Saskatchewan from 1923 to 1957

Location	Years of First Severe Attack in Outbreaks
Saskatchewan	
Battleford	1930, 1940, 1951
Nipawin	1937, 1953
Hudson Bay	1939
Prince Albert National Park	1933, 1939, 1952
Manitoba	
Duck Mountain	1938, 1947
Riverton	1945
Riding Mountain	1941
Swan River	1938
Whitemouth	1946, 1952
Crow Duck Lake	1925, 1938, 1950

Wellington (1952) has shown that the larvae of the forest tent caterpillar require moist air to carry out their activities effectively. He also described the weather conditions in northern Ontario that preceded population increases. These were high frequency of the number of passing cyclonic centres, especially during the spring and summer months, and the southwestern or southern origin of the majority of the air masses. However, Wellington (1952) mentioned that it is not safe to assume that the same types of air masses will give the same effects in all regions.

Reference to Figures 1 and 2 and to the weather maps of Wellington (1950, pp. 316, 317) suggest certain relationships between weather and the frequency of infestations in the Prairie Provinces, but admittedly the biological data are rather scant. When the deviations of the average number of cyclones from the long term average were strongly positive (from 1931 to 1934), the number of infestations tended to be low. The largely negative deviations of 1936 to 1939 were followed in 1939 and 1940 by a number of widely scattered infestations. This may indicate that the trajectory and source of cyclonic weather systems in the Prairie Provinces are more important than the frequency of cyclonic activity in the development of outbreaks. This should be a promising field of future study, but the results will depend on the accuracy of recording infestation and intensity and the careful analysis of patterns of weather systems like those recognized by Turnock (1959).

Although there are uncertainties about the role of weather in the rise of outbreaks in the central region, it is clear that weather contributed to the decline of two outbreaks in the 'fifties. Blais *et al.* (1955) reported high temperatures in early May in northern Ontario and southern Manitoba in 1953, followed by freezing temperatures and a long period of cold weather. In areas where aspen flushed early, the young foliage was destroyed by the frost, and most of the larvae that survived the cold died from starvation. In areas where the aspen flushed late, the foliage was not destroyed by frost, but temperatures suboptimal for feeding were suspected of killing the majority of the young larvae. The role of weather in ending the second outbreak is not so clear. Prentice (1954) noted that egg bands protected from outside winter temperatures yielded about 80 per cent hatch, whereas those that overwintered under field conditions showed only about 31 per cent hatch. Some of the overwintering mortality within the egg may have been caused by unfavourable weather, but confirmation is lacking.

TABLE II.

Mortality of Aspen by Basal Area in Square Feet in Relation to Defoliation Caused by the Forest Tent Caterpillar on Twenty-eight One-quarter Acre Plots in Manitoba and Saskatchewan 1951-1956

Tree size by D.B.H. in inches	Average basal area per plot	Per cent mortality by class of defoliation index		
		0–35	40–105	110–210
1–4	7.4	4.9	9.3	7.4
5+	12.8	2.5	4.9	3.5

With 2 and 25 degrees of freedom F for small trees = 2.72 and for large trees F = 0.82. No significant difference in mortality between classes.

The three classes of defoliation represent one year of very light defoliation; one year of light to one year of light and one year of severe defoliation; one year of light and two years of moderate to severe defoliation.

Defoliation and Tree Mortality

Trembling aspen is subject to attack by so many disease organisms (Riley, 1955) and insects that it is difficult to prove the role of the tent caterpillar in the dying of trees. This difficulty was experienced in Minnesota (Duncan and Hodson, 1958) where a diagnosis of the causes of tree mortality was made following a tent caterpillar outbreak that was active from 1948 to 1956. This study indicated that tree mortality caused solely by the tent caterpillar was negligible. Similarly, it has been shown (Ghent, 1958) that severe infestations of the forest tent caterpillar did not hasten death of over-mature stands of aspen in the Lake Nipigon area of Ontario, and tree mortality was attributed almost entirely to wind breakage.

In the present study, two sources of data were available to determine if the two outbreaks in the early 'fifties caused any appreciable mortality of aspen in Manitoba and Saskatchewan. These sources were 38 mortality plots, ¼ to ⅕ acre in size, strategically located in infested stands in the two provinces and 132 tenth-acre inventory plots in Saskatchewan.

Twenty-eight of the mortality plots were established in 1950, so the defoliation history of these is known. Most of these were established in pure stands, seven of which were near Rennie and Lac du Bonnet in eastern Manitoba; four were located between Sprague and Hadashville in southern Manitoba and 13 in the Prince Albert - Waskesiu region of Saskatchewan. Most of the plots were even-aged, with a tendency to maturity, but they varied in site, density, and severity of defoliation. As indicated above, the outbreak in the vicinity of these plots rarely lasted more than three years. For the purpose of comparing the possible effect of defoliation on tree mortality, defoliation is expressed as an index (Table II), which is the accumulated percentage of defoliation over a three-year period. Hence, an index of zero would indicate no defoliation, whereas a maximum index of 300 would denote complete defoliation each year for three consecutive years. The mortality figures are grouped by three classes of defoliation indices (Table II). The classes were selected so as to provide almost equal numbers of plots in each class. The tree mortality in lightly defoliated plots was not significantly less than in severely defoliated plots, indicating that defoliation causes no appreciable mortality.

The second source of mortality data consisted of inventory plots, on which data were made available by the Saskatchewan Department of Natural Resources.

TABLE III.

Basal area of living and dead aspen in selected 1/10-acre inventory plots of Saskatchewan Department of Natural Resources. Mortality from all factors accumulated from 1949 to 1954.

	Number plots	d.b.h. inches	Average basal area in sq. ft.	Per cent trees dead by basal area
Infested, mixed stands	21	1–4	2.0	21.6
		5+	16.5	2.0
Non-infested, mixed stands	83	1–4	0.6	16.9
		5+	9.7	4.7
Infested, pure stands	11	1–4	1.7	27.8
		5+	22.2	4.8
Non-infested, pure stands	19	1–4	2.1	11.2
		5+	13.8	4.0

NOTE: Analysis of variance in a 2 x 2 table making allowance for disproportionate sub-classes (lower diameters only) give F values of 2.5 and 0.04 for "infestation" and "stand composition", respectively, with 1 and 130 degrees of freedom. Above differences in mortality not considered significant.

These were established in 1949 and retallied in 1954. In a preliminary analysis, many of the plots were rejected. These were plots on which the average d.b.h. of aspen was less than three inches and plots on which aspen was less than 25 per cent of the stand. The accepted plots were located near Dore Lake and Montreal Lake, and the stands varied considerably in age and density. Also, 32 of the plots were in stands that were attacked by the forest tent caterpillar from 1951 to 1953, whereas the other 102 plots fell outside but in close proximity to outbreak areas.

Comparisons of mortality in the inventory plots are made on the assumption that if the insect causes appreciable killing of aspen, there should be a trend of higher mortality in plots within the outbreak area than those falling outside the area of attack. The 132 plots used in the final analysis fall into four categories with respect to stand composition and infestation history (Table III). It is clear that tree mortality was fairly high on all plots. However, mortality in attacked stands was not significantly higher than in unattacked stands regardless of composition or diameter class.

Although the two sources of data fail to show that the forest tent caterpillar killed significant numbers of trees during the most recent outbreaks, the data show a trend of higher mortality among suppressed trees in the lower diameter class. The outbreaks in the 'fifties were of shorter duration than others recorded earlier. If the recent outbreaks had lasted another year, undoubtedly higher mortality would have resulted, because mortality of aspen ranging from nil to 80 per cent was reported (Duncan and Hodson, 1958) following the 1933-1938 outbreak in Minnesota. However, in the latter case drought may have contributed to tree mortality.

Effect of Defoliation on Increment

A survey was conducted in 1958 as a step toward a broader study to estimate the degree of increment loss that may have been caused by outbreaks that were active in the 'fifties. In the meantime, similar but more comprehensive studies were published by Duncan and Hodson (1958), so we could see little point in continuing our studies beyond the preliminary stage.

In this survey four or five trees on the mortality plots were cut and sections removed from the stump level and mid-crown. The volume of the cut trees

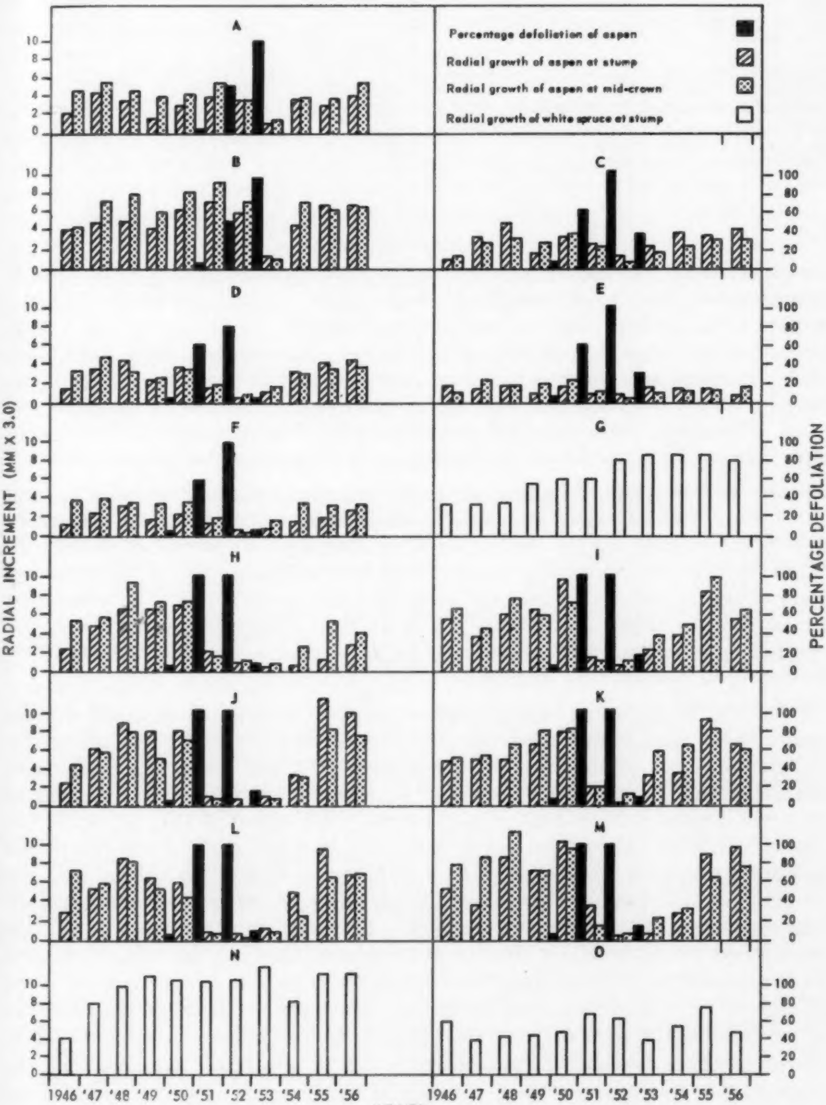

Fig. 3. Radial growth of individual aspen and white spruce trees and defoliation of aspen by the forest tent caterpillar in two forest regions. A-G, Dore Lake and Big River regions of Saskatchewan. H-O, Whiteshell and Moose Lake regions of Manitoba.

TABLE IV

Approximate areas of aspen stands in Manitoba and Saskatchewan infested by the Forest Tent Caterpillar from 1951 to 1953 by regions.

Region	Approximate area infested by acres
Whiteshell, Manitoba	52,669
Southeastern Manitoba	249,387
Prince Albert region, Saskatchewan	378,492
Prince Albert National Park, Saskatchewan	276,480
Meadow Lake, Saskatchewan	516,057
Buffalo Narrows-Beauval, Saskatchewan	37,439
Total	1,510,524

was ascertained, and the annual ring widths were measured along three radii of each section. The radial growth of white spruce was also measured for comparison with aspen in three of the principal regions. The selected trees were some of those on which individual defoliation estimates had been taken since 1950. It is therefore possible to indicate the effect of defoliation on radial increment of sample trees that ranged from 26 to 86 years of age and from 2″ to 8.6″ d.b.h. Increment losses estimated therefrom were then projected to obtain some appreciation of volume losses on the plots and throughout the infested area.

One or two years of light to moderate and one year of severe (almost complete) defoliation depressed the radial growth at the stump level and mid-crown only in the year of highest defoliation (Fig. 3, A-F). Recovery of growth the following year was practically complete. Trees with one year of light and two years of severe defoliation did not show recovery until one or two years after the last year of severe defoliation (Fig. 3, H-M). Hence the recent forest tent caterpillar outbreaks generally caused a striking reduction in radial growth over the four-year period, 1951 to 1954.

In order to obtain a rough estimate of the volume loss, it is assumed that the basal area of the increment for the 1951-1954 period should have equalled that for the four-year period prior to the beginning of the outbreak. Admittedly this assumption is not completely valid because white spruce trees on some of the plots showed a slight decline in growth in 1953 and 1954 (Fig. 3, G, N, O). The actual basal area of the sample trees was 91.6 per cent of the theoretical, indicating that each year from 1951 to 1954, inclusive, the loss in basal area was 2.1 per cent of the total. To express this percentage in terms of volume requires several assumptions that are not adequately supported by scientific data. These assumptions are discussed by Duncan and Hodson (1958). The volume of aspen on the mortality plots ranged from 2,163 to 3,226 cu. ft. per acre with an average of 2,695 cu. ft. per acre in the two provinces. Therefore, the estimated volume loss on the plots for each of the four years amounted to about 57 cu. ft. per acre. This compares favourably to a loss of 2¼ cords per acre for fully stocked aspen stands over a three-year period in Minnesota (Duncan and Hodson, 1958).

The forest inventories of Manitoba and Saskatchewan show that many stands affected by the last outbreak were not fully stocked, averaging about 722 cu. ft. per acre. Applying this volume to the total area affected (Table IV), the annual growth loss of 2.1 per cent suggests an annual volume loss of about 22 million cubic feet of wood over the four-year period.

Summary

Infestations of the forest tent caterpillar have been active in Manitoba and Saskatchewan almost every year from 1923 to 1953. These infestations can be recognized as constituting several outbreaks, all differing in their directions of extension.

Outbreaks in the early 'fifties ended abruptly, and infestations in individual stands generally caused not more than two years of almost complete defoliation. This degree of defoliation was not sufficiently severe to cause appreciable tree mortality. It did cause increment loss estimated at 8.4 per cent of the total basal area in stands covering about one and a half million acres of aspen in the two provinces.

Acknowledgments

The authors acknowledge the help of the forest services of Saskatchewan and Manitoba in providing certain data on tree mortality and the resources of aspen in the two provinces. Thanks are extended to the Forest Biology Rangers of the Winnipeg Laboratory for their assistance in collecting and tabulating some of the information described herein. We also acknowledge the interest of Dr. W. L. Sippell, who offered suggestions in the interpretation of data.

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Life-History of the Seed-Corn Maggot, *Hylemya cilicrura* (Rond.) and of *H. liturata* (Mg.) (Diptera: Anthomyiidae) in Southwestern Ontario[1]

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The seed-corn maggot, *Hylemya cilicrura* (Rond.), infests a wide range of hosts in all provinces of Canada and is also a pest in the Yukon and the Northwest Territories. *H. liturata* (Meig.) frequently occurs in smaller numbers along with *H. cilicrura*. *H. liturata* has not been recorded from Alberta, Saskatchewan, and Manitoba (Brooks, 1951). Detailed accounts of the species have not been published by Canadian entomologists, though *H. cilicrura* has been known as a pest of cultivated crops in Canada for over 70 years. In southwestern Ontario the seed-corn maggot is one of the most serious soil pests of vegetables and field crops.

This is a report on investigations conducted at Chatham, Ontario, from 1951 to 1958 on the species complex, hosts, seasonal history and habits of the adults, factors affecting infestation, and natural control.

Species Complex

In southwestern Ontario, *H. cilicrura* and *H. liturata* usually infest the same crops at the same time and apparently have identical seasonal histories. This close association was noted in England by Meade (1883), who observed that *H. liturata* was far less abundant than *H. cilicrura*. Van Dinther (1953) in Holland and Miles (1952) in England were so impressed with these similarities that they referred to both species as the "bean seed flies". Miles was unable to distinguish between eggs, larvae, or pupae of the two species. In Canada, Brooks (1951) found the eggs and first-instar larvae identical but distinguished both the second and third instars on the basis of size, thickness of the body wall, and the size, shape, and position of two of the posterior tubercles. According to Huckett (1924), reliable specific anatomical differences are lacking in the adult females of the two species.

At Chatham the ratio of females to males for 5,441 adults of the seed-corn maggot reared in the laboratory was 2,694 ♀♀ : 2,747 ♂♂, or 1♀ : 1♂. The ratio of *H. cilicrura* to *H. liturata* for over 2,000 males reared from various crops at different times during the years of study was 9:1. In this paper the term *seed maggots* refers to this composite population of *H. cilicrura* and of *H. liturata* in southwestern Ontario; *seed-corn maggot* refers to *H. cilicrura* only.

Hosts and Distribution in Canada

The seed-corn maggot was first recorded a pest in Canada in 1885, when Jack (1887) reported an infestation in green wax beans in Chateauguay, Quebec. Lochhead (1901) first reported its occurrence in Ontario in 1900 on beans in Lambton County. Beans, seed corn, and seed potatoes were reported by Caesar (1931) as the most important hosts of the seed-corn maggot in Ontario; in addition to these hosts Dustan (1948) recorded cucumber and squash. Matthewman *et al.* (1950) mentioned it as a minor pest of onions, cabbage, and radish in the Ottawa district. In Manitoba, radishes are also infested by the maggot (Kelleher, 1958). An unusual infestation occurred in garden beets in Nova Scotia (Fox, 1951). Forbes and Finlayson (1957) recorded it as a pest of cruci-

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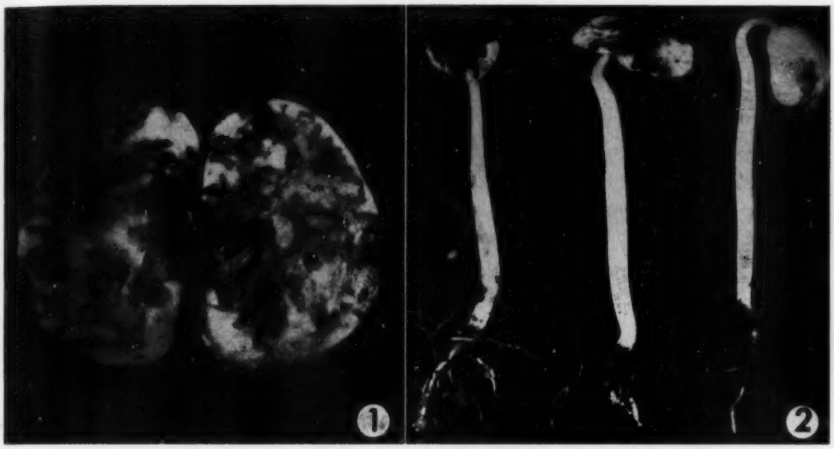

Fig. 1. Lima bean seed infested by seed maggots.
Fig. 2. "Bald-headed" condition of beans caused by seed maggots.

ferous crops in British Columbia. References to its attacks on various crops across Canada have been made almost annually in the *Canadian Insect Pest Review*. MacNay (1953) compiled a map of the known distribution of the seed-corn maggot in Canada.

This is an account of plants attacked in southwestern Ontario and a discussion of some of the factors involved. A few records of infestations are included which, while of negligible economic importance, are of interest because of their unusualness.

Beans

Approximately 60,000 acres of dry beans are grown annually in Ontario (Ontario Dept. Agr., 1958); these beans are undoubtedly the most important host of the seed maggots. All garden varieties of beans are susceptible to attack and infestations are common in lima, wax, and kidney beans grown commercially for processing. Infestations occur annually; it is a rare year in which some fields are not disked under and reseeded. The germ is destroyed in severely infested seeds (Fig. 1). When the germ is not destroyed, the seedlings are spindly and usually "bald-headed" (Fig. 2), although true leaves may be formed. These seedlings seldom develop into bearing plants or, if they do, they mature late, the pods are dwarfed, the yield is low, and the seed is of poor quality.

In recent years, the widespread use of seed protectants on large seeds has reduced the economic importance of seed maggots. However, a few infestations in treated beans were observed, suggesting an adaptation by the maggots. From 1 to 10 maggots were found in stems just below the soil surface. These infestations occurred in cold, wet springs and it is perhaps significant that when moisture is excessive the testa frequently becomes dislodged from the cotyledons and remains in the soil almost at the point of seed placement. Normally, the testa is forced above ground, carrying with it much of the original dosage of protectant (Miller and McClanahan, 1958). Shedding the testa in the soil, therefore, renders the fleshy cotyledons more vulnerable to maggot attack. Should the habit of stem infestation increase, the value of seed dressings may be considerably reduced.

Soybeans

There has been a steady increase in the acreage of soybeans grown in Ontario. In 1957, 252,000 acres were grown (Ontario Dept. Agr., 1958), or approximately four times the combined acreage of other bean varieties. In Ontario this crop was practically free from insects before 1951. In that year 80 per cent of the plants in a nine-acre field in Essex County were infested. In 1953, hundreds of acres throughout Kent and Essex counties were destroyed and since then infestations have been observed annually.

Packard (1951), dealing comprehensively with insects of soybeans in the United States, did not mention the seed-corn maggot. Subsequent reports in the *Co-operative Economic Insect Report*, published weekly by the United States Department of Agriculture, reveal that the seed-corn maggot is now common and widespread in many of the soybean-growing areas.

Peas

Although undetected infestations may have occurred for some time, the seed-corn maggot was first recorded as attacking canning peas in Ontario in 1953. Because the crop is usually planted between mid-April and mid-May, the seedlings are normally well established before the small overwintered generation lays its eggs. A heavy seeding rate of four to six bushels per acre results in a dense stand and an infestation would have to be severe before a reduction in the number of seedlings would be noticed. However, the pea crop is potentially an important host of the seed maggots and processing companies in southwestern Ontario now supply growers with treated seed.

Crucifers

In southwestern Ontario, small numbers of maggots were frequently reared as secondary pests from the stems or roots of cauliflower, brussels sprouts, early cabbage, broccoli, kohlrabi, turnip, and radish. In 1954 and 1956, mature heads of cauliflower were infested by the maggots. The infestations were associated with a brown rot in the curds, but whether the maggot or the rot was secondary was not determined. In both years, the infestations developed early in July after a period of overhead irrigation. Up to 25 per cent of the plants in individual fields of a localized area of approximately 10 acres were unmarketable. If attack of the mature heads becomes general, new problems in control and insecticide residues will arise. Infestations of *H. brassicae* (Bouché) have caused similar browning and rotting in heads of cauliflower and brussels sprouts (Brooks, 1951).

Potato

The role of the seed-corn maggot as a carrier of *Erwinia atroseptica* (van Hall, 1902), the causative bacterium of the blackleg disease of potato, was first demonstrated by Leach (1926). Both *H. cilicrura* and *H. liturata* are involved, according to Ramsey *et al.* (1932), who refer to *H. liturata* [= *H. trichodactyla* Rond.] as the "seed potato maggot".

The early potato crop in southwestern Ontario is frequently infected with blackleg but even the worst infections seen were light to moderate. Light maggot infestations are common in potato in this area but these have not been associated with the disease. Begg (1959) reported severe injury to seed pieces and stems in a 15-acre field of early potatoes in southwestern Ontario.

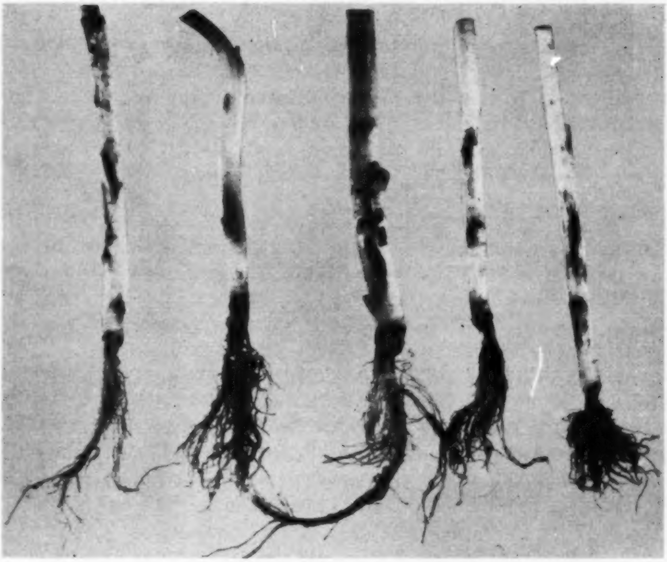

Fig. 3. Stems of tobacco transplants infested by seed maggots.

Tobacco

An outbreak of seed maggots occurred in flue-cured tobacco in Ontario in 1958 when approximately 30,000 acres of seedlings were infested in the counties of Norfolk, Oxford, Brant, and Elgin. Up to 72 per cent of the plants in individual fields were tunnelled by the maggots (Fig. 3). Most of the damage occurred to seedlings transplanted before May 28. Visible symptoms, other than a general slowness of growth, were absent even though numerous maggots were present in individual stems. Infestations generally could be detected only by dissecting healthy-appearing plants. Although a few acres were disked under and replanted, careful observations showed that infested plants fully recovered by mid-July. At harvest these plants were as vigorous and productive as those that had been replanted.

A similar, but more severe, outbreak occurred in 1959 necessitating extensive replanting of tobacco planted before June 1. It is significant that in both years the tobacco was infested with maggots of all instars three to four days after transplanting, indicating that the infestation was present in the soil *before* the seedlings were set in the field. (The infestation was not carried into the field with the greenhouse-grown seedlings). The fall cover crop of rye is usually ploughed down one to two weeks before the tobacco is transplanted and this is considered an important factor in these outbreaks of seed maggots. (The significance of this is discussed under "Attraction to Newly Disturbed Soil"). Unusually large numbers of the overwintered generation were also present in the springs of 1958 and 1959.

Cucurbits

Occasional infestations occurred in the seeds of cucumber, muskmelon, squash, watermelon, pumpkin, and gourd. In 1955 and 1956 infestations were observed in the stems of seedling cucumbers.

Cereals, Buckwheat, and Alfalfa

Adults of the maggots were obtained from emergence cages placed in fields of wheat, rye, oats, barley, and buckwheat. On one occasion, adults of the seed-corn maggot were reared from an infested alfalfa plant. In plots where rows were seeded heavily, the numbers of flies emerging from barley, oats, and rye were almost as high as from beans and peas. Relatively few were obtained from wheat and buckwheat.

Corn

Seed maggots are not usually serious pests of corn in southwestern Ontario. Infestations were light even before the general use of seed dressings for wireworm control.

Onion

Onions are occasionally infested by seed maggots in southwestern Ontario. They have been found in association with the onion maggot, *H. antiqua* Mg., and were reared from cooking and Spanish onions grown from seed, Dutch sets, transplant seedlings of Spanish onions, and silverskin pickling onions.

The seed-corn maggot is a pest of early onions in Michigan, according to Merrill and Hutson (1953).

Pepper

An unusual infestation occurred in 1955 when light infestations of the seed-corn maggot were observed in pepper fruits in two market gardens involving about four acres. Eggs were laid on the fruits early in August and the maggots, on hatching, burrowed into the peppers. As growth progressed the entry holes became scarcely discernible and infestations in the early stages could be determined only by cutting the peppers open. The presence of maggots favoured the development of rot in the peppers and, as the maggots matured, infested fruits were easily distinguishable. Adults began to emerge on August 26 from these infested fruits. This, and the occurrence of larvae in the curds of cauliflower, are the only records in these studies indicating that oviposition occurred on growing plants. According to Brooks (1951), eggs of the seed-corn maggot are laid on the stems or leaf petioles of cruciferous seedlings in much the same manner as those of *H. brassicae*.

Notes on Generations

Two methods were used to study the number of generations and the emergence period for each generation.

(a) From early April to the end of October, dry beans, lima beans, peas, oats, wheat, rye, and barley were sown thickly in 30-foot rows at three-day intervals. After 14 days, 12 emergence cages were placed on each row. An emergence cage consisted of a two-gallon sap pail inverted and forced into the soil to a depth of two to three inches, the sides being banked another two to three inches. The positively phototactic adults emerged into a screw-top, glass vial fitted into a hole punched near the upper end of the upturned pail. Vials containing flies were removed from the pail cages, capped for later examination, and replaced with empty vials. Approximately 600 cages were used annually from 1951 to 1958. The flies were collected and numbers recorded daily.

(b) From 1955 to 1958, flour baits were used extensively and very effectively. The bait, made of whole-wheat flour and water kneaded into a ball about 1.5 inches in diameter, was covered with two inches of soil and marked by

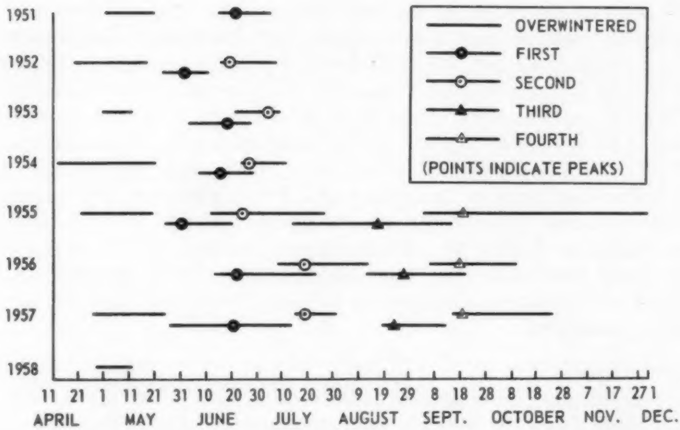

Fig. 4. Number of generations of seed maggots and the period and peak of emergence of each for the years 1951 to 1957 and the period of emergence of the overwintered generation in 1958, Chatham, Ontario. Based on records from approximately 600 emergence cages each year.

a stake. After 14 days, one emergence cage was placed over each bait. Flies frequently laid eggs close to the baits before they were covered. Flies from this source far outnumbered those obtained from caged crop rows.

When large numbers of puparia were required for laboratory rearing or other purposes, these were easily obtained. Twenty-five to 30 baits, each with about 200 cubic inches of surrounding soil were dug after 18 to 20 days, placed in a large metal tub, and covered with water for an hour. Frequent stirring with a paddle dislodged the puparia. These floated to the surface and were removed with a wire-mesh strainer. The puparia were stored at 40° F. and 75 per cent relative humidity until required.

Number of Generations

Fig. 4 shows that there were four generations of seed maggots in southwestern Ontario for the years 1955 to 1957, inclusive. This is considered normal. The caging of bean, pea, oat, and barley plants did not reveal the presence of a third or fourth generation from 1951 to 1954; the occurrence of these generations was demonstrated only with baits. The size of the third and fourth generations was so small that they were not detected in field populations.

These observations are similar to those of Miles (1948), who recorded three to four generations in England, and of Ristich (1950), who observed four generations in New York. By establishing thermal constants for the different life stages, Strong and Apple (1958) concluded that the theoretical number of generations in Wisconsin in 1957 was 5.26. This compared with four complete and two partial generations that they observed in the field.

In Ontario, Caesar (1931) reported "three generations or one full generation and two partial", whereas Dustan (1948) reported only one generation.

Overwintered Generation

Adults of the seed maggots are among the first insects of economic importance to appear each year in southwestern Ontario. The winter is spent in a

puparium three to six inches in the soil, although the rare occurrence of adults in early spring suggests that a few adults may hibernate. The overwintered generation is very small and shows no defined peak in numbers. To determine the time of year the overwintered puparia were formed, 25 baits were placed in the soil approximately every three days between July 22 and September 18, 1957. After 14 days, one cage was placed over each bait. Flies emerged in the fall of 1957 from all baits placed in the soil on, and before, August 13. No flies emerged from these baits in the spring of 1958 and only empty puparia were sifted from the areas. Flies began to emerge on April 28, 1958, from the areas baited on, and after, August 16. This indicates that there was no diapause in the first and second generations (see emergence periods of these generations, Fig. 4) and that the overwintered generation is comprised of puparia of the small third and fourth generations.

First Generation

Maggots infesting early-seeded crops such as peas, corn, and spring cereals are usually those from the overwintered generation of flies. Similarly the first-generation maggots frequently infest cole crops, radishes, and onions. When the season is cold and wet as in 1951 and 1956, this generation is delayed and also causes most of the damage to beans.

Second Generation

A second generation was clearly defined in every year except 1951, when beans were extensively damaged by first-generation maggots. A large population of flies resulted from this infestation but subsequent infestations did not develop in cultivated crops. The second generation, which usually infests beans, is the most destructive in southwestern Ontario.

Third and Fourth Generations

Neither the third nor the fourth generation is of economic importance in southwestern Ontario, although fall-seeded cereals and leguminous crops are sometimes lightly infested.

Habits of Adults

Activity Associated with Weather

The adults become active in southwestern Ontario during the latter part of April. Throughout May and June the adults are among the most abundant of the area. Most adult activity occurs between 60° and 85° F. As the temperature increases beyond 85° F. in July and August, activity decreases and above 90° F. the adults are difficult to find in direct sunlight. On these occasions, however, they can often be observed in shaded areas, particularly in dense vegetation near the soil surface. At 53° F., activity is very sluggish and consists mainly of short flights a few inches above the ground. On bright days during winds of 25 to 35 miles per hour, the adults were frequently observed clinging to leaves of shrubs, trees, and other vegetation.

Hovering and Swarming

Both species were observed in a hovering type of swarming each year. Individuals appeared suddenly from ground level, hovered momentarily, darted swiftly and erratically to heights of 25 to 30 feet and returned. The hovering of individuals was very similar to that of the Syrphidae. At times large numbers of individuals took part in this activity and collectively moved up and down or backward and forward somewhat resembling swarms of mosquitoes or

TABLE I

Numbers and sex of *H. cilicrura* and of *H. liturata* adults captured in mixed swarms on various dates, Chatham, Ontario*

Date	*H. cilicrura*		*H. liturata*	
	Males	Females	Males	Females
May 18, 1951	17		1	
May 26, 1952	18	3		
June 1, 1952			8	
June 22, 1953	45	16	152	15
June 23, 1953	90	1		
July 6, 1954	21	1		
Total	191	21	161	15

*Identification of females to species was not positive.

midges. Swarms were observed at numerous sites, including lawns, golf courses, pasture land, gardens, and also in open barns, sheds, and carports. Reid (1940) also observed the hovering of the species.

The hovering and swarming could not be associated with any particular time of day or with weather conditions, but activity was obviously greatest during peaks of abundance. As examples, in 1957 the first adults of the season were observed on April 26 and, on April 27, swarming was widespread although only small numbers were involved. Large numbers of the first generation emerged on June 24 and, on June 26, thousands of flies were observed hovering low over a golf course.

The species and sex of the swarming flies were determined on numerous occasions by capturing adults with a net. Typical results are given in Table I. The swarms were comprised mainly of males. It was common to find both *H. cilicrura* and *H. liturata* in the same swarms and on only one occasion, June 1, 1952, was a swarm population sampled in which *H. cilicrura* was not present; *H. liturata* was absent from swarms more often. June 22, 1953, was the only date on which *H. liturata* exceeded *H. cilicrura* in numbers in any of the swarms sampled.

The presence of both sexes and authentic records of mating swarms in many other Diptera suggest that the swarming is associated with mating. However, mating was not observed in these flights or in laboratory rearing. Miles (1950) stated, "Mating appeared to take place on the wing in sunshine". Ristich (1950) recorded several occasions on which mating was observed and intimated that union occurred during flight. In 11 years of intensive study, Reid (1940) observed mating in cages on only three occasions.

Feeding

In the early morning the adults may be seen on vegetation obtaining moisture from droplets of dew. Nectar in dandelion flowers appears to be a source of food; females, particularly, were commonly found in early spring among the dandelion petals. When engorged adults were dissected, their abdomens contained a clear, viscous fluid. In mid-June, 1955, large numbers fed on honey dew excreted by the English grain aphid, *Macrosiphum avenae* (F.) [= *M. granarium* (Kby.)], which was abundant on cereals at that time.

Attraction to Newly Disturbed Soil

The attraction of seed maggot adults to freshly cultivated soil was observed by van Dinther (1953), Miles (1950), Reid (1940), and others. This proclivity was noted early in the studies at Chatham in a swampy area where large numbers of flies congregated in fresh tractor tracks. In cultivated fields, the flies may appear within minutes after cultural equipment has passed over the soil. Mechanical disturbance exposes moist, warm earth which attracts the flies and stimulates them to oviposit. Attraction to newly disturbed soil is less evident during fall cultural operations but this may merely reflect the lower populations at that time. The significance of the habit and its relationship to oviposition and subsequent infestations was studied.

To determine whether oviposition occurred before planting, four 20- x 4-foot strips of garden soil were raked until warm, moist soil was brought to the surface. This was done during peaks of activity of the first and second generations. Flies were immediately attracted to the area and were very active. The soil was left exposed to oviposition for one day, and 25 baits were then placed at random in each strip. A cage was immediately placed over each bait to exclude further oviposition. A check strip consisted of 50 baits placed at random in undisturbed soil in the same area. Within three weeks, flies had emerged into almost all of the 100 cages in the strips of disturbed soil, the number per cage ranging up to 77 and averaging 19. Eleven flies were obtained from the 50 baited areas in undisturbed soil.

It was also necessary to determine whether maggots would mature in soil devoid of visible food. Eggs were placed on the surface of moist soil taken at random from a fertile field. The maggots matured, presumably feeding on the organic matter in the soil. The puparia were somewhat smaller than those from well-fed maggots. The resulting flies were correspondingly small. This observation was corroborated in a field test by leaving a raked area exposed to oviposition for one day during a peak oviposition period and then placing 100 cages at random over the area. Flies emerged into many of these cages but not in such numbers as when baits were used.

Beans are the most seriously infested crop in southwestern Ontario because they are planted during the flight of the large first generation. Often before seeding, eggs or maggots are present in the soil as the result of females depositing eggs during the preparation of the seed bed. The drilling operation itself produces conditions that stimulate oviposition. When infestations are absent or light, it may be because cultural operations have not coincided with the maturation of the females. In these studies no evidence was obtained to show that oviposition occurred after planting and as a direct result of the presence of seeds or seedlings.

These findings suggest that the species are primarily saprophytes. They indicate also that economic infestations are determined mainly by cultural operations rather than by the host species, many of which are not closely related. They also suggest a reasonable explanation for the spottiness of infestations which has puzzled investigators. The moisture- and heat-holding capacities of soils vary considerably and, when such soils are disturbed, many micro-environments are created, some being more attractive than others to ovipositing females. Seed subsequently sown in the attractive areas becomes infested, while that sown in surrounding areas may escape.

Many investigators have associated the presence of decaying organic matter with infestations by the seed-corn maggot and this important point is not dis-

counted. In 1954, two severe infestations in southwestern Ontario were evidently associated with organic matter. In one instance, one acre of a five-acre field was planted to spinach in early spring. The crop failed (not because of maggots) and was disked under on May 20 when the remaining four acres were also cultivated. The entire five acres were planted to field beans on June 1. On June 28, 80 per cent of the beans grown where the spinach had been were infested; none in the remaining four acres were damaged. No other conclusion seems possible than to attribute the infestation to the attractiveness of the decaying spinach to ovipositing females. In the other instance, infestations developed in cucumber seed that had been planted with chopped barley as an "extender"; "non-extended" seed in the same field escaped injury.

Natural Control

At Chatham, 16 cynipid parasites were reared from about 1,000 field-collected puparia in 1954. These were identified as *Trybliographa* sp., possibly *ruficornis* Ashm., by Dr. O. Peck, Entomology Research Institute, Research Branch, Ottawa, Ontario. The species was not obtained in rearings after 1954. *Aleochara bipustulata* (L.) (Staphylinidae), was reared from field-collected puparia in 1956 but not thereafter; about 0.3 per cent of the puparia were parasitized. From extensive collections of *H. cilicrura* puparia in Canada, Wishart (1957) obtained *Aleochara bilineata* Gyll. from all provinces except Saskatchewan, *Trybliographa rapae* (Westw.) from all provinces except Prince Edward Island and Alberta, and *A. bipustulata* from Ontario and Manitoba only; none of these species were obtained at Chatham.

The anthomyiid predator *Coenosia tigrina* F. was observed on numerous occasions attacking and feeding on seed-corn maggot adults. The attacks were vigorous and certain and it is noteworthy that in England this predatory species is aptly called the "tiger fly" (Miles, 1948). *C. tigrina* has not been abundant in southwestern Ontario and it is not an important natural control agent.

During examination of thousands of flies in this study, an unusual condition suggestive of parasitism or predation was observed. One or two circular holes about one-third of the venter of the abdomen in extent were found in six females and five males collected in the field. The abdomens were empty but, remarkably, the specimens were alive and very active when captured. Although the condition was more suggestive of parasitism than of predation, no parasites emerged from field-collected adults that were annually held in study cages. An apparently similar condition observed by Strong *et al.* (1958) in Wisconsin was ascribed to an unidentified entomorphthoraceous fungus.

Summary

Hylemya cilicrura (Rond.) and *H. liturata* (Meig.), closely related species of root maggots, usually occur together in infestations in southwestern Ontario. They are the most serious soil pests of beans (*Phaseolus* spp.), soybeans, and peas in the area; to a lesser degree they infest crucifers, cereals, potatoes, cucurbits, corn, tobacco, onions, peppers, buckwheat, and alfalfa. Examination of over 2,000 males indicated that the ratio of *H. cilicrura* to *H. liturata* was 9:1; the sex ratio of *H. cilicrura* was 1:1.

Adults emerged from mid-April to early December. There are usually four generations a year. The first and second generations are large and economically important; the third and fourth are small and economically unimportant. The adults are active mainly at temperatures between 60° and 85° F. Hovering and swarming were observed annually and are possibly associated with

mating. The species are primarily saprophagous. Females are attracted to newly disturbed soil and are stimulated to oviposition. Thus infestations are determined mainly by cultural operations rather than by the host species and potential infestations are often present in the soil before the host crop is planted. Adults are preyed upon by an anthomyiid, *Coenosia tigrina* (F.); the parasites *Trybliographa* sp., possibly *ruficornis* Ashm. (Cynipidae), and *Aleochara bipustulata* (L.) (Staphylinidae) were reared from puparia. None are considered important natural control agents.

Acknowledgments

The authors are indebted to Mr. G. F. Manson, Officer in Charge of the Chatham laboratory, for many helpful suggestions during the study. The competent assistance of Mr. A. J. De Lyzer in much of the field work is gratefully acknowledged.

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Huckett, H. C. Males of the genus *Hylemya sens. lat.* from North America, having dorsal bristles on mid metatarsus, with descriptions of new species (Muscidae, Diptera). *Bull. Brooklyn Ent. Soc.* 48: 10-19. 1953.

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A New Species of *Monellia* Oestlund, with a Synopsis of the Aphids Attacking Hickory and Walnut in Canada

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The walnut and hickory aphids comprise the genera *Chromaphis* Walker, *Monellia* Oestlund and a somewhat aberrant species of *Myzocallis* Passerini. *Chromaphis* contains a single species that occurs widely on walnut in Europe and North America. *Monellia* is larger, is restricted to North America, and has been recorded from both walnut and hickory. Four species of *Monellia* occur in Canada, one of which is herein described as new.

The life cycles of all of the species are essentially the same. Development is completed on the same species of host plant, and with the apparent exception of fundatrices, all viviparous forms are winged. The life histories of some of the species have been discussed in considerable detail by Davidson (1914).

Key to Walnut and Hickory Aphids in Canada

1. Cornicle short, cylindrical 2
   Cornicle poriform, but sometimes on a small, rounded tubercle 3
2. Alatae yellow, with an unguis that is shorter than the base of antennal segment VI; alatoid nymphs without pigmentation on body, with four-segmented antennae, with four longitudinal rows of setae on dorsum of abdomen (Fig. 1) .... *Chromaphis juglandicola* (Kalt.)
   Body of alatae largely black when alive, and with large tubercles on thorax and anterior abdominal terga (Fig. 8); alatoid nymphs with six-segmented antennae, with large pigmented spots around the bases of the dorsal setae, with only two longitudinal rows of setae on dorsum of abdomen (Fig. 2) .... *Myzocallis (Tinocallis) caryfoliae* (Davis)

3. Costal margin of forewing in alatae completely dark (Fig. 17); alatoid nymph with only two dorsal, longitudinal rows of pointed, or slightly capitate setae on dorsum of abdomen, and usually without pigmentation on dorsum of abdomen when macerated (Fig. 5) .... *Monellia costalis* (Fitch)
   Costal margin of forewing in alatae without pigmentation except for a small irregular spot on stigma; alatoid nymph with more than two longitudinal rows of setae on dorsum of abdomen, or with pigmented spots at bases of setae 4
4. Most of dorsal abdominal setae in alatae and alatoid nymphs with pigment around their bases (Figs. 3, 9) .... *Monellia caryae* (Monell)
   Without pigmented spots as above 5
5. Alatae and alatoid nymphs with four longitudinal rows of setae on dorsum of abdomen that are about equal in length (Figs. 4, 10) .... *Monellia caryella* (Fitch)
   Alatae and alatoid nymphs with two, longitudinal rows of long setae on dorsum of abdomen and two to five rows of smaller setae between them (Figs. 6, 12) .... *Monellia microsetosa* new species

Chromaphis juglandicola **(Kaltenbach)**

1843 Kaltenbach, J. H. Monographie der Familien der Pflanzenläuse: 151. *Lachnus juglandicola.*
1857 Koch, C. L. Die Pflanzenläuse: 224. *Callipterus juglandicola.*
1870 Walker, F. Zoologist V: 2000. *Chromaphis juglandicola.*
1881 Buckton, G. B. Monograph British Aphididae: 32. *Pterocallis juglandicola.*
1912 Essig, E. O. Pomona Coll. J. Ent. 4: 763. *Chromaphis juglandicola.*
1914 Davidson, W. M. Bull. U.S. Dep. Agric. 100: 2. *Chromaphis juglandicola.*
1920 Baker, A. C. Bull. U.S. Dep. Agric. 826: 27. *Chromaphis juglandicola.*
1926 Theobald, F. V. Aphididae of Great Britain 2: 355. *Chromaphis juglandicola.*
1952 Palmer, M. A. (Thomas Say Foundation) 5: 67. *Chromaphis juglandicola.*
1952 Borner, C. Mitt. Bot. Ges. Bieh. 3: 60. *Chromaphis juglandicola.*
1957 Borner, C. *In* Sorauer Handb. d. Pflanz. V: 81. *Chromaphis juglandicola.*

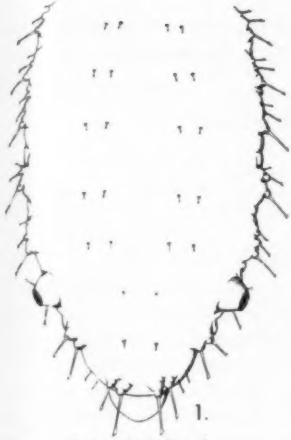
Alate Viviparous Female.—Colour in life: Yellow, with dark brown or black pigment on apices of antennal segments, on tarsi, a spot near apices of hind femora and near bases of wing veins. Colour when macerated: Colourless, but with pigmented spots as indicated above.

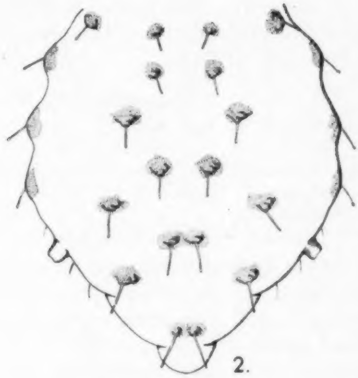
Morphology: Antennal setae pointed, shorter than half the basal diameter of antennal segment III; antennal segment III with six to eight secondary sensoria, other segments without secondary sensoria. Lengths of antennal segments: III, 0.35 - 0.4 mm.; IV, 0.18 - 0.2 mm.; V, 0.15 - 0.17 mm.; VI, 0.08 - 0.1 mm. + 0.025 mm. Dorsum of head with pointed setae. Length of hind tibia 0.8 - 0.85 mm. Dorsum of abdomen with pointed setae arranged essentially as in Fig. 7. Venter of abdomen with slender, pointed setae arranged in two irregular, transverse rows on each segment. Cornicle short, roughly cylindrical, with two setae near base on ventral surface. Cauda knobbed. Anal plate weakly indented. Length 1.5 - 2.0 mm.

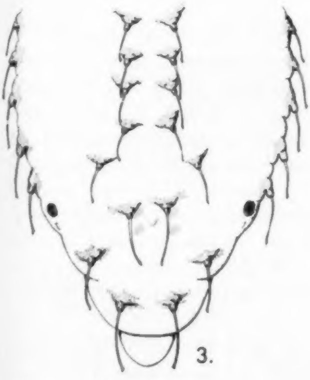
Alatoid Nymph.—Colour in life: Largely yellow with a small, fuscous area on apical antennal segment and near apex of hind femora. Colour when macerated: Essentially as in living form insofar as pigmented areas are concerned.

Morphology: Antennal setae mostly capitate and shorter than the basal diameter of antennal segment III. Antenna four-segmented, without secondary sensoria. Lengths of antennal segments: III, 0.2 - 0.25 mm.; IV, 0.1 mm. + 0.025 mm. Most of setae on dorsum of head capitate, those near posterior margin shorter. Length of hind tibia 0.45 - 0.55 mm. Dorsa of abdominal segments with short, inconspicuous, capitate setae; larger abdominal setae capitate in life, but membranous apices often collapse producing funnel-shaped apices. Cornicle short, essentially as in alatae. Venter of abdomen with pointed setae. Cauda and anal plate rounded. Length 2.0 mm.

Distribution.—Occurs widely in Europe and North America. Specimens examined from: B.C., on *Juglans* sp.; ONT., on *Juglans* sp.


1.
C. juglandicola


2.
M. (T.) caryfoliae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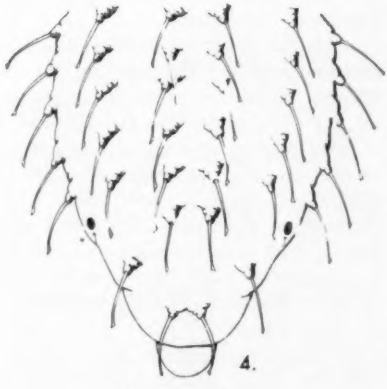
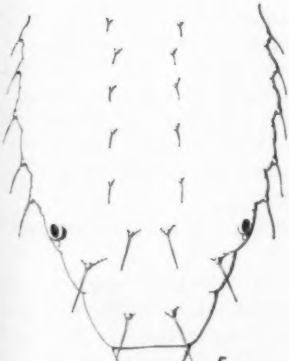
M. caryae


4.
M. caryella


5.
M. costalis


6.
M. microsetosa

Figs. 1-6. Dorsa of abdomens of alatoid nymphs.

Comments.—This species is readily recognized by the characters given in the key. The life history and economic importance has been discussed in some detail by Davidson (1914).

Myzocallis (Tinocallis) caryfoliae (Davis)

1910 Davis, J. J. Ent. News 21: 198. *Callipterus caryfoliae.*
1917 Baker, A. C. J. Econ. Ent. 10: 422. *Myzocallis fumipennellus.*
1922 Oestlund, O. W. Rep. St. Ent. Minn. 19: 136. *Melanocallis caryfoliae.*
1931 Hottes, F. C., and T. H. Frison. Bull. Ill. Nat. Hist. Surv. 19: 250. *Melanocallis fumipennella.*
1954 Quednau, W. Mitt. Biol. KentAnst. Berl. 78: 28. *Tinocallis fumipennella.*

Alate Viviparous Female.—Colour in life: Head, thorax and abdomen mostly blue black, but abdomen with a dorsal series of conspicuous waxy, white spots; antenna largely colourless except for some fuscous pigmentation on segments I, II and apices of segments III, IV, V, and VI; tarsi, foretibiae and apical four-fifths of middle and hind tibiae pale, other parts of legs light to dark fuscous; wings largely hyaline but with some pigmentation on stigma, along costal margin and at base of cubitus of forewing. Colour when macerated: Pterothorax dark; head and abdomen essentially as in Fig. 8; legs and wings essentially as in living specimen, but lighter.

Morphology: Antennal setae pointed, about half the basal diameter of antennal segment III; segment III with 9-16 secondary sensoria, other segments without secondary sensoria. Lengths of antennal segments: III, 0.45 - 0.55 mm.; IV, 0.3 - 0.35 mm.; V, 0.25 - 0.3 mm.; VI, 0.075 - 0.1 mm. + 0.075 - 0.1 mm. Disc of head with four small seta-bearing tubercles. Dorsum of prothorax with four, small tubercles; pterothorax with two large, conical tubercles near posterior margin. Length of hind tibia 0.65 - 0.7 mm. Venation of wings normal. Dorsum of abdomen with series of lateral and dorsal tubercles as indicated in Fig. 8; each tubercle with a small, pointed, seta at apex. Venter of each abdominal segment with two irregular transverse rows of pointed setae. Cornicles short, cylindrical. Cauda knobbed. Anal plate very deeply indented. Length 1.5 - 2.0 mm.

Alatoid Nymph.—Colour in life: Head and body dark brown to blue black; without dorsal, waxy, white spots; appendages essentially as in alate viviparous female, but slightly more fuscous. Colour when macerated: Mostly colourless but with large pigmented tubercles at the bases of all setae.

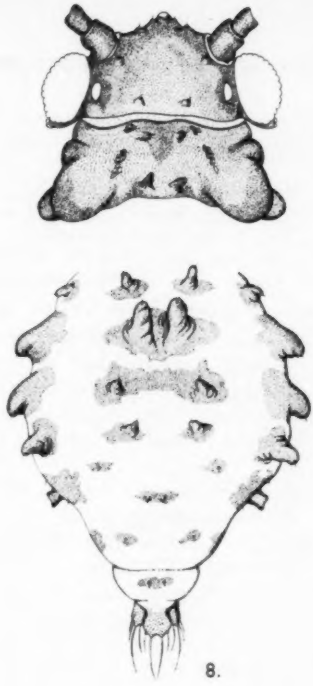
Morphology: Antennal setae pointed; much shorter than half the basal diameter of antennal segment III; without secondary sensoria. Lengths of antennal segments: III, 0.2 - 0.25; IV, 0.1 - 0.125 mm.; V, 0.1 - 0.125 mm.; VI, 0.075 - 0.1 mm. + 0.075 mm. Dorsa of head and thorax with slender, distinctly capitate setae. Length of hind tibia 0.4 - 0.5 mm. Chaetoxy of dorsum of abdomen essentially as in Fig. 2. Ventral abdominal setae pointed, arranged in two irregular transverse rows on each segment. Cornicle short, cylindrical. Cauda and anal plate rounded. Length 1.2 - 1.5 mm.

Distribution.—Known to occur only on *Carya* spp. Specimens examined from: ONT., on *Carya ovata* (Mill.) Koch.

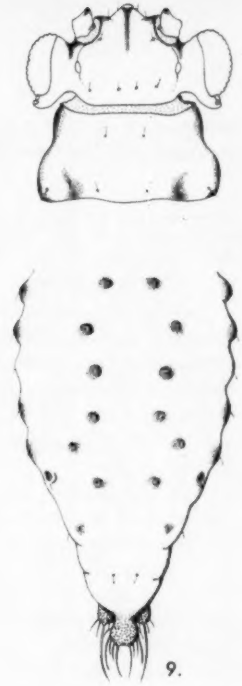
Comments.—This species is readily recognized by the dark colour of the living forms and the prominent thoracic and abdominal tubercles in macerated material. A further means of recognition is the fact that colonies are produced mainly on the upper surfaces of the leaves.

Baker (1917) considered this species to be a synonym of *Aphis fumipennella* Fitch, a view which was subsequently accepted by Hottes and Frison (1931) and Quednau (1954). However, Fitch (1855) described a yellow species with dusky

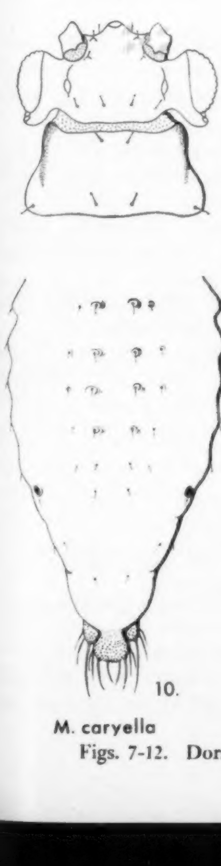
C. juglandicola



M. (T.) caryfoliae



M. caryae



M. caryella

M. costalis

M. microsetosa

Figs. 7-12. Dorsa of heads and abdomens of alate viviparous females.

wings, and as such a form has not been associated with *caryfoliae* it seems best to conclude that two distinct species are involved.

Monellia caryeae (Monell)

1879 Monell, J. Bull. U.S. Geol. Geogr. Surv. 5: 31. *Callipterus caryae.*
1910 Gillette, C. P. J. Econ. Ent. 3: 367. *Monellia caryae.*
1914 Davidson, W. M. Bull. U.S. Dep. Agric. 100: 19. *Monellia caryae.*
1931 Hottes, F. C., and T. H. Frison. Bull. Ill. Nat. Hist. Surv. 19: *Monellia caryae.*

Alate Viviparous Female.—Colour in life: Yellow, with dark pigment around antennal sockets, on apical halves of antennal segments I and II, at apices of antennal segments III, IV, and V, on apical half of unguis, on margins of prothorax, a spot near apices of fore and hind femora, on lateral lobes of abdominal segments I, II, IV, V, and around bases of setae on abdominal terga I-VII. Colour when macerated: Largely colourless, but with pigmented spots as when living.

Morphology: Antennal setae pointed, the longest ones one-half the basal diameter of segment III. Antenna six-segmented; segment III with four to six secondary sensoria. Lengths of antennal segments: III, 0.25 - 0.3 mm.; IV, 0.2 - 0.225 mm.; V, 0.2 - 0.225 mm.; VI, 0.125 - 0.15 mm. + 0.125 - 0.15 mm. Dorsa of head and thorax with pointed setae that are longer than the basal diameter of segment III. Venation of wings normal for genus; radial sector of forewings absent. Length of hind tibia 0.6 - 0.65 mm. Dorsum of abdomen with two longitudinal rows of setae, those of the fifth and sixth abdominal segments displaced laterally. All abdominal setae pointed. Ventral abdominal setae pointed, arranged in two transverse rows on each segment. Cornicle poriform, sometimes raised on a small rounded tubercle. Cauda knobbed. Anal plate strongly indented. Length 1.5 - 2.0 mm.

Alatoid Nymph.—Colour in life: Mostly yellow but with fuscous spots around the tubercles on which the dorsal setae are situated, and at apices of antennal segments. Colour when macerated: Colourless, but with pigmented areas as when living.

Morphology: Antenna six-segmented, with pointed setae that are shorter than the basal diameter of segment III. Secondary sensoria absent. Lengths of antennal segments: III, 0.25 - 0.275 mm.; IV, 0.15 - 0.2 mm.; V, 0.15 - 0.2 mm.; VI, 0.125 mm. + 0.125 mm. Length of hind tibia 0.45 - 0.5 mm. Dorsal chaetotaxy essentially as in Fig. 3. Cornicle poriform. Cauda and anal plate rounded. Length 1.5 - 2.0 mm.

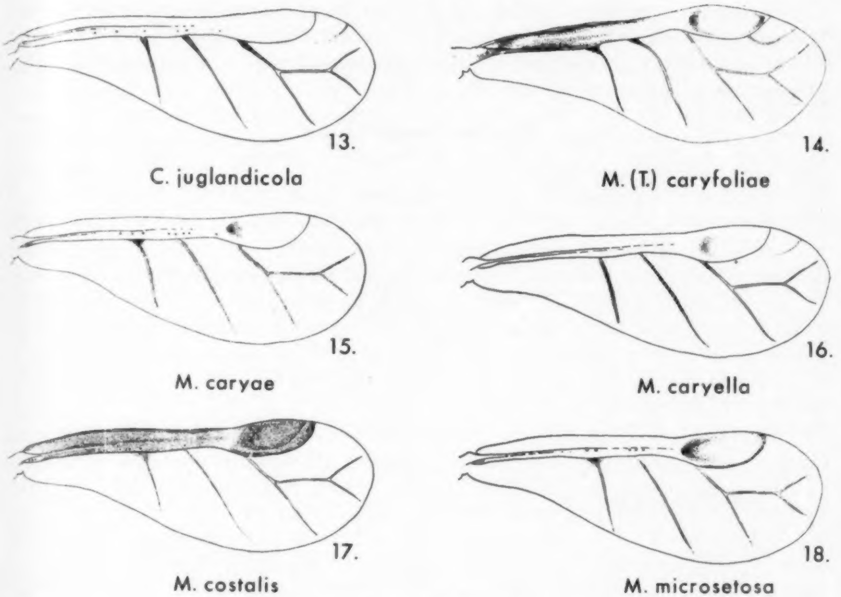
Distribution.—Widespread in North America and has been recorded from hickory and walnut. Specimens examined from: N.B., on *Juglans* sp.

Comments.—This species is readily distinguished by the fuscous spots on the dorsum of the abdomen in the alatae and in the alatoid nymphs. It is evidently very rare in Canada and only a few males and alatoid nymphs have been collected. The notes on and illustrations of the alate viviparae are from specimens collected in Illinois and North Carolina.

Monellia caryella (Fitch)

1854 Fitch, A. Trans. N.Y. Agric. Soc. 14: 867. *Aphis caryella.*
1856 Fitch, A. Trans. N.Y. Agric. Soc. 16: 448. *Callipterus caryella.*
1887 Oestlund, O. W. Bull. Geol. Nat. Hist. Surv. Minn. 4: 45. *Monellia caryella.*
1914 Davidson, W. M. Bull. U.S. Dep. Agric. 100: 26. *Monellia caryella.*
1931 Hottes, F. C., and T. H. Frison. Bull. Ill. Nat. Hist. Surv. 19: 252. *Monellia caryella.*
1952 Palmer, M. A. Thomas Say Foundation V: 68. *Monellia caryella.*
1957 Börner, C. *In* Sorauer Handb. d. Pflanz. 5: 85. *Monellia caryella.*

Alate Viviparous Female.—Colour in life: Largely yellow with dark pigmentation apices of antennal segments, along margins of prothorax, a spot near



Figs. 13-18. Right forewings.

apex of hind femora and the tarsi are slightly dusky. Wings hyaline, but veins, especially the cubitus are slightly bordered. Colour when macerated: Mostly colourless, pigmented areas essentially as when living.

Morphology: Antennal setae pointed, much shorter than one-half the basal diameter of antennal segment III. Segment III with 8-12 secondary sensoria, other segments without sensoria. Lengths of antennal segments: III, 0.45 - 0.5 mm.; IV, 0.25 - 0.275 mm.; V, 0.25 - 0.275 mm.; VI, 0.125 + 0.125 mm. Setae on disc of head pointed or weakly capitate, slightly shorter than basal diameter of antennal segment III. Setae on thorax slightly capitate and slightly longer than those on disc of head. Wings, normal for genus; radial sector very weakly developed or absent. Length of hind tibia 0.85 - 0.9 mm. Dorsum of abdomen with four longitudinal rows of setae; those on anterior segments on distinct, but small papillae and often distinctly capitate; setae on posterior segments usually pointed.

Alatoid Nymphs.—Colour in life: Mostly yellow, but with some pigmentation at apices of antennal segments. Colour when macerated: Colourless, but pigmentation as when living.

Morphology: Antennal setae pointed much less than basal diameter of segment III. Antenna six-segmented, without secondary sensoria. Lengths of antennal segments: III, 0.25 - 0.275 mm.; IV, 0.175 - 0.2 mm.; V, 0.175 - 0.2 mm.; VI, 0.125 - 0.15 mm. + 0.1 - 0.125 mm. Setae on disc of head three or four times as long as basal diameter of antennal segment III, capitate or with funnel-shaped apices. Setae on dorsum of thorax about as long and the same shape as those on disc of head. Length of hind tibia 0.5 - 0.55 mm. Dorsal abdominal chaetotaxy as in Fig. 4. Venter of abdomen with two irregular, transverse rows of setae on each segment. Length 1.5 - 2.0 mm.

Distribution.—Occurs widely in North America on hickory and walnut. Specimens examined from: ONT., on *Carya ovata* (Mill.) Koch.

Comments.—This species is readily distinguished by the absence of dorsal pigmentation and the distinctive chaetotaxy.

Monellia costalis (Fitch)

1854 Fitch, A. Trans. N.Y. Agric. Soc. 14: 869. *Aphis caryella* var. *costalis*.
1854 Fitch, A. Ibid: 870. *Aphis marginella*.
1917 Baker, A. C. J. Econ. Ent. 10: 424. *Monellia costalis*.
1931 Hottes, F. C., and T. H. Frison. Bull. Ill. Nat. Hist. Surv. 19: 252. *Monellia costalis*.

Alate Viviparous Female.—Colour in life: Yellow with black pigment on dorsum of head, on prothorax, on abdomen and on forewing as indicated in Figs. 11, 17, on costal margin of hind wing, on lateral margins of pterothorax, on anterior margin of hind wing, on base and apex of antennal segment III, on apices of antennal segments IV and V, on most of unguis and spots near apices of fore and middle femora. Colour when macerated: Largely colourless, with the same pigmented areas as in life.

Morphology: Antennal setae pointed, shorter than basal diameter of antennal segment III. Antenna six-segmented; segment III with 4-6 secondary sensoria on the basal pigmented portion, other segments without secondary sensoria. Lengths of antennal segments: III, 0.4 - 0.45 mm.; IV, 0.3 - 0.325 mm.; V, 0.3 - 0.325 mm.; VI, 0.2 - 0.225 mm. + 0.2 - 0.225 mm. Dorsa of head and thorax with pointed setae that are slightly longer than the basal diameter of antennal segment III. Venation of wings normal. Length of hind tibia 0.6 - 0.65 mm. Dorsum of abdomen with two median rows of pointed setae; lateral abdominal setae pointed; ventral abdominal setae pointed, arranged in two irregular transverse rows on each segment. Cornicle poriform, sometimes raised on a slight tubercle. Cauda knobbed. Anal plate strongly indented. Length 1.7 - 2.0 mm.

Alatoid Nymph.—Colour in life: Yellow, apices of antennal segments III, IV, V, most of unguis, with dark pigment. Colour when macerated: Largely colourless, but pigmented areas as when alive.

Morphology: Antenna six-segmented, with pointed setae that are shorter than the basal diameter of segment III. Dorsa of head and thorax with pointed setae that are equal to or longer than basal diameter of antennal segment III. Lengths of antennal segments: III, 0.35 - 0.4 mm.; IV, 0.225 - 0.3 mm.; V, 0.225 - 0.25 mm.; VI, 0.175 - 0.2 mm. + 0.175 mm. Length of hind tibia 0.5 - 0.55 mm. Dorsum of abdomen with two median, rows of setae that have distinctly funnel-shaped apices. Lateral abdominal setae long, with distinctly funnel-shaped apices. Ventral abdominal setae pointed, arranged in two irregular, transverse rows on each segment. Cornicles poriform. Cauda and anal plate rounded. Length 1.5 - 2.0 mm.

Distribution.—Widely distributed in Eastern North America, and mainly on hickory. Specimens examined from: ONT., on *Carya ovata* (Mill.) Koch.

Comments.—This species is most readily recognized by the abundant dark pigment on the anterior margins of the fore- and hind wings.

Monellia microsetosa, new species

Alate Viviparous Female.—Colour in life: Largely yellow, distinguished from *caryella* only by a broad, pigmented band near the base of antennal segment III; sometimes with pigment on dorsa of thorax and abdomen essentially as in Fig. 18. Colour when macerated. Essentially as when alive.

Morphology: Frontal tubercles poorly developed. Antennae shorter than the body; segment III with three to eight secondary sensoria, other segments

without them. Lengths of antennal segments: III, 0.3 - 0.425 mm.; IV, 0.25 - 0.3 mm.; V, 0.275 - 0.3 mm.; VI, 0.175 - 0.225 mm. + 0.15 - 0.2 mm. Antennal setae pointed shorter than half the basal diameter of segment III. Disc of head smooth, with pointed setae that are about equal to the basal diameter of antennal segment III. Apical segment of rostrum with two to four setae in addition to the usual three apical pairs and minute basal pair; 0.075 mm. long. Chaetotaxy of prothorax as in Fig. 18. Pterothorax normal for genus. Venation of wings normal for genus; radial sector of forewings weakly developed or absent. Tibial setae mostly pointed, slender, less than apical diameter of hind tibia; each tibia with four or five short, spinelike setae at apex. Each first tarsal segment with two dorsal setae and five ventral setae. Length of hind tibia 0.6 - 0.7 mm. Dorsum of abdomen with two median, longitudinal rows of relatively long, pointed setae and two to five shorter, finer setae between each pair, (Fig. 18). Ventral abdominal setae pointed, arranged in two irregular transverse rows on each segment. Cornicle poriform. Cauda knobbed. Anal plate deeply indented. Integument with sharp, spicules on antennae, on apical halves of tibia, on tarsi, sparsely on abdominal terga, on cauda and on anal plate. Length 1.7 - 2.0 mm.

Alatoid Nymph.—Colour in life: Yellow with some pigmentation at apices of antennal segments. Colour when macerated: Colourless, but pigmentation as in living forms.

Morphology: Antennal setae pointed, mostly less than half the basal diameter of segment III. Secondary sensory absent. Lengths of antennal segments: III, 0.25 - 0.3 mm.; IV, 0.2 - 0.225 mm.; V, 0.2 - 0.225 mm.; VI, 0.175 - 0.2 mm. + 0.15 - 0.175 mm. Setae on disc of head, pointed to minutely capitate. Apical rostral segment with three or four setae in addition to the usual three apical pairs and minute basal pair; 0.75 mm. long. Setae on dorsum of thorax about the same length as those on disc of head. Legs essentially as in alate viviparous female, but basal segments of tarsi without dorsal setae. Length of hind tibia 0.45 - 0.5 mm. Chaetotaxy of dorsum of abdomen essentially as in Fig. 6. Ventral abdominal setae pointed, arranged in two irregular, transverse rows on each segment. Cauda and anal plate rounded. Length 1.8 - 2.0 mm.

Holotype.—Alate viviparous female, Vittoria, Ont., July 7, 1956 (W. R. Richards) on *Carya* sp. No. 7030 in Canadian National Collection.

Paratypes.—Eighteen alate viviparous females, five alatoid nymphs. Data as for holotype. One alate viviparous female, Highlands, N. C. Aug. 27, 1957 (W. R. Richards), on *Juglans* sp. One alate viviparous female, Seneca, S.C., Aug. 24, 1957 (W. R. Richards) on *Carya* sp.

Comments.—The northern alate viviparous females of this species are easily confused with *caryella*, but can be distinguished by the dorsal chaetotaxy, and the broad band of pigment near the base of antennal segment III. The southern specimens, although structurally identical with the specimens that were collected in Ontario, are readily distinguished by the relatively abundant dark pigment as indicated in Fig. 18.

Summary

Hickory and walnut are attacked by six species of aphids in Canada, one of which is described as new. Keys, illustrations and brief descriptions are provided for the species known to occur in Canada.

Acknowledgments

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Two New Species of the Genus *Hyperaspis* (Coleoptera: Coccinellidae)[1]

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Among the more important predacious coccinellids in eastern North America is *Hyperaspis binotata* auct., which has been considered a general feeder on *Toumeyella numismaticum* (P. & M.), *Pulvinaria* spp., and other scale insects. A review of the specimens identified as *H. binotata* in the collections of the Forest Insect Laboratory, Sault Ste. Marie, has revealed, not only *H. binotata* (Say), but two apparently new species, descriptions of which are given in this paper. In addition to the material at Sault Ste. Marie, specimens were obtained from the Canadian National Collection and the Forest Biology Laboratory, Winnipeg, Manitoba.

The discovery of these two new species suggests that *H. binotata* (Say) is not as polyphagous as once thought, but may be restricted to certain types of scale insects. Only *H. congressis* n. sp. is associated with *Toumeyella numismaticum*, whereas both *H. binotata* (Say) and *H. paspalis* n.sp. are associated with scale insects on deciduous trees.

[1]Contribution No. 599, Forest Biology Division, Research Branch, Department of Agriculture, Ottawa, Canada.

Both new species are quite similar to *H. binotata* (Say), all three species having the following characters in common: Colour shining black, ♂ with head, and anterior and lateral margins of pronotum variably marked with white. Punctation of head shallow and dense, of thorax shallow and more widely spaced. Interspaces of head alutaceous. Elytra each with a bright red spot about the middle of the disc. Shape of body moderately convex. Ventrally black with coarse lateral punctation. Chromosome numbers are identical (Smith, 1960).

Hyperaspis congressis, new species
(Figs. 1-2)

Length 3.2 mm. (2.7 mm. - 3.5 mm); width 2.5 mm. (2.0 mm. - 2.8 mm). Sides of elytra almost parallel in middle third. Punctation of elytra distinct, irregular, rugose near scutellum. Reddish spot somewhat transverse.

Apices of femora, occasionally tibiae and tarsi, and lateral edges of abdominal segments testaceous. Prosternal lines long, converging to an acute apex near the anterior edge of sternum. Metacoxal arc finely punctate within. Male genitalia; Aedeagus[2] (Fig. 2) very asymmetrical, apex wide and obliquely truncate, one side deeply concave, the other sinuous with a large convexity between which and the base the margin is straight. Paramera as long as aedeagus, stout, outer margin concave at base, sides otherwise nearly parallel to a broadly rounded apex. Apex of sipho arcuate with a well-defined sclerotized plate at base of ridges.

Female genitalia: Spermatheca spherical, retort-shaped, with a long narrow duct. Bursa urn-shaped, with a stout angular projection from the distal end.

Holotype: ♂, Savanne, Ont., 7-VIII-59, ex *Pinus banksiana* (S-59-4302-01); Slide No. W-396; Type No. 7015 in the Canadian National Collection, Ottawa.

Allotype: ♀, same data, no slide.

Paratypes: 7 ♂ ♂, 19 ♀ ♀ same data; 8 ♂ ♂, 6 ♀ ♀, Agawa, Lake Superior, Ont. 28-VII-56; 3 ♂ ♂, 11 ♀ ♀, Walford, Ont., 15-VIII-50; 2 ♂ ♂, 11 ♀ ♀, Prince Albert, Sask., 5-VII-59 (Brooks-Wallis); 3 ♂ ♂, 7 ♀ ♀, Hudson Bay, Sask., 25-VIII-54 (Brooks-Wallis).

Other Localities: Manitoba; 4 ♀ ♀, Beausejour, 20-VIII-53 (Brooks-Kelton); 1 ♀, Reynolds, 10-VI-53, (Brooks-Kelton); 2 ♂ ♂, 2 ♀ ♀, Victoria Beach, 18-VIII-53 (Brooks-Kelton); 1 ♂, Fairford, 28-VI-56; 1 ♀, Grandview, 27-VII-44; 1 ♀, Pine Falls, 3-VI-41; 3 ♂ ♂, 2 ♀ ♀, Sandilands Forest Reserve, 17-V-38, 16-VIII-45, 21-VII-55, 4-VII-55; 1 ♀, Stead, 15-VIII-55.

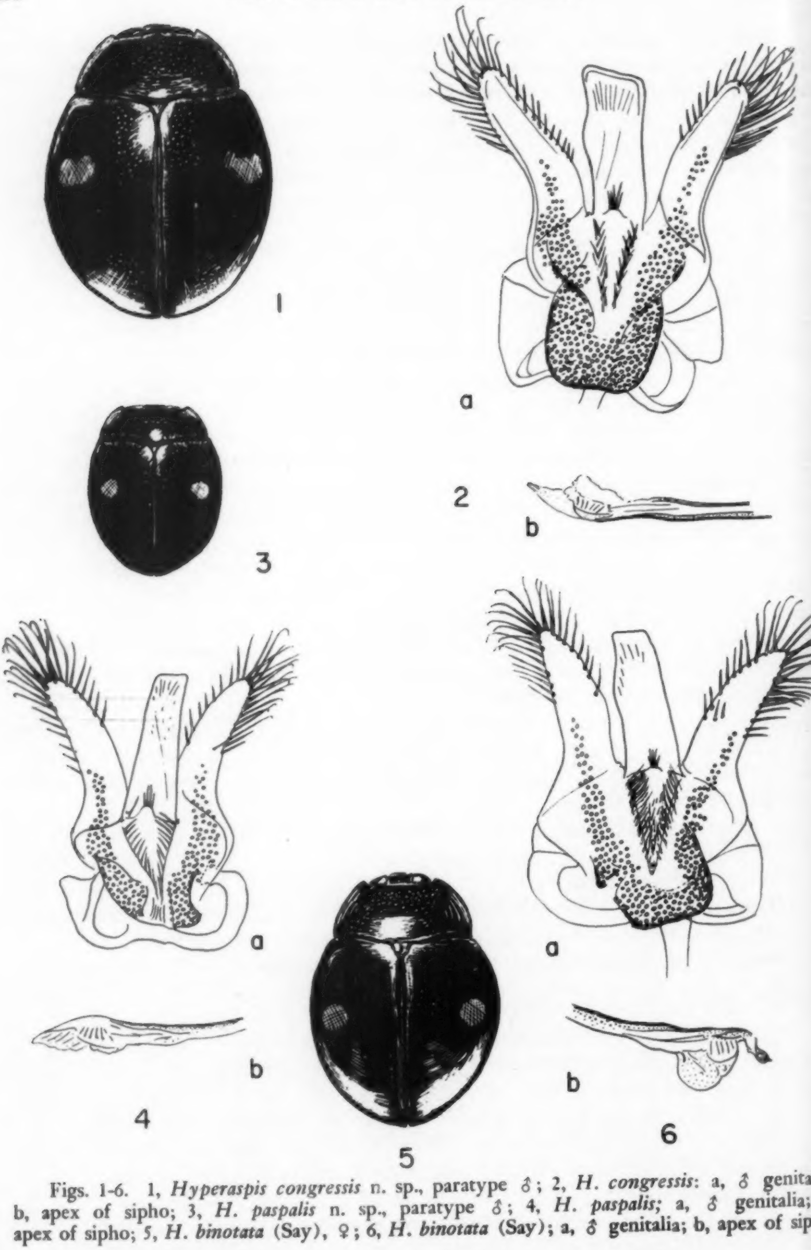
Ontario; 1 ♀, Fort William, 9-V-49; 2 ♂ ♂, German, 6-VI-45; 1 ♀, Gogama, 30-VII-49; 1 ♂, Hawk Lake, 21-V-45; 1 ♂, Lost Bay, 3-VII-45, 1 ♂, McIntosh, 21-VIII-54.

Saskatchewan; 1 ♀, Holbein, 19-VIII-45; 1 ♂, Prince Albert, 4-VII-55.

Remarks: This species may be distinguished from *H. binotata* (Say) by its larger average size, pale edges to the abdominal sterna, and irregular aedeagus. There is some variation in size but the greater number of individuals fall within .2 mm. of the mean. There is no apparent difference between males and females in size. The elytral spot, although usually somewhat transverse in this species, may be ovoid or almost round.

H. congressis has been found in large numbers along the eastern shore of Lake Superior when the adults may be thickly settled in crevices in the bark of trees as well as in the beach drift. In September this species has been found pupating in the litter beneath jack pine trees infested with *Toumeyella*. The pupae were attached to sticks, pieces of grass, dried leaves, and the shrivelled fronds of bracken fern. Among the pupae were some uneclosed adults, that is

[2]Figures of genitalia made from specimens mounted in Hoyer's Fluid.



Figs. 1-6. 1, *Hyperaspis congressis* n. sp., paratype ♂; 2, *H. congressis*: a, ♂ genitalia; b, apex of sipho; 3, *H. paspalis* n. sp., paratype ♂; 4, *H. paspalis*; a, ♂ genitalia; b, apex of sipho; 5, *H. binotata* (Say), ♀; 6, *H. binotata* (Say); a, ♂ genitalia; b, apex of sipho.

they had split the pupal skin and were fully coloured but had not emerged from the pupal cell. In all areas where the species could be associated with a host, this host was *Toumeyella numismaticum*.

The name *congressis* is derived from the Latin *congressus* meaning a gathering or assembly, and here refers to the habit of the adults on certain occasions.

The name also honours those members of the Tenth International Congress of Entomology who found this insect in such large numbers during a visit to the Sault Ste. Marie area.

Hyperaspis paspalis, new species

(Figs. 3-4)

Length 2.4 mm. (2.1 mm. - 2.9 mm.); width 1.9 mm. (1.7 mm. - 2.3 mm.). Sides of elytra arcuate; punctures of elytra relatively large, deep, and irregular. Anterior side of femora white in ♂, black in ♀. Abdominal sternites black or with a greyish cast. Prosternal lines, parallel or only slightly convergent, not meeting near front edge of sternum. Metacoxal arc impunctate within. Spot on the average rounded rather than transverse.

Male genitalia: Aedeagus (Fig. 4) long, knife-like, with virtually parallel sides and an obliquely truncate apex. Apex of sipho arcuate, not definitely sclerotized at base of ridges. Paramera digitate, shorter than aedeagus and narrowing towards the apex.

Female genitalia: Smaller but otherwise as in *congressis*.

Holotype: ♂, Iron Bridge, Ont., 17-VIII-59, ex *Quercus rubra* (S-59-6503-01), Slide W-389; Type No. 7016 in the Canadian National Collection, Ottawa.

Allotype: ♀, same data, no slide.

Paratypes: 23♂♂, 39♀♀, same data; 9♂♂, 26♀♀, Walsingham, Ont., 12-VIII-59.

Other Localities: Ontario; 1♀, St. Williams, 29-VII-59 (S-59-5403-01), 1♂, St. Williams, 6-IX-50, ex *Castanea* sp. (S-58-9091), 1♀, Sault Ste. Marie, 3-IX-54 (W. Y. Watson); 1♂, Gravenhurst, —VIII-54; 1♀, Ridgeway, 24-VII-59, ex. *Tilia* sp. (S-59-5392-01); 1♀, South Cayuga, 9-VII-59, ex. *Tilia* sp. (S-59-5391-01); 1♂, 3♀♀, Normandale, 18-VI-31 (W. J. Brown); 1♂, 1♀, Blackburn, 12-IV-37 (W. J. Brown).

Remarks: The size of the body and structure of the prosternal lines and aedeagus will distinguish this species from both *congressis* and *binotata*. Although the size variation is apparently greater in this species than in *congressis*, the majority of the individuals still fall within .2 mm. of the mean. The spot shows little or no tendency to become transverse.

Little is known about the biology of *paspalis* except that specimens have been taken from *Castanea* sp., *Tilia* sp., and *Quercus* sp., the last known to be infested with a *Lecanium* scale. The name *paspalis* is derived from the Latin *paspalum*, a kind of millet, and here refers to the shape of the adult, being like that of millet seed.

Hyperaspis binotata (Say)

(Figs. 5-6)

This is not a common species in eastern Canada, being restricted to southern Ontario and southern Quebec, where its distribution broadly mingles with that of *paspalis* and overlaps slightly the southern distribution of *congressis*. Although similar to each of the new species, *binotata* (Say) is intermediate in size and more polished. The aedeagus is convex on one side but otherwise parallel-sided, and the apex of the sipho is sharply curved rather than arcuate. The prosternal lines are like those of *congressis*, whereas the aedeagus is more like that of *paspalis*.

The characters of *binotata* are either like those of the two new species or are almost intermediate between them, and suggest that *binotata* might be nothing more than a hybrid between the other two species. Other evidence, however, points conclusively to its being a valid species. The apparent intermediate nature of some characters remains constant throughout the range of the insect, even though this overlaps the ranges of the other two species. The host preferences

of *congressis* and *paspalis* are such as to reduce to a minimum the chance of these species coming together to mate. And finally, there is no cytological evidence of hybridity (Smith, pers. comm.).

The following key will fit into that of Casey (1899), continuing from the *binotata* part of couplet 12 (p. 124);

1. Prosternal lines converging to an acute apex near the anterior margin of the sternum, size 2.7 mm. or more 2
1. Prosternal lines nearly parallel, not meeting near the anterior margin of the sternum, aedeagus narrow, parallel-sided, size not exceeding 2.9 mm. .... *paspalis*, n. sp.
2. Ventral surface of abdomen black, aedeagus with a slight convexity on one side .... *binotata* (Say)
2. Ventral surface of abdomen with lateral areas testaceous, aedeagus very asymmetrical .... *congressis*, n. sp.

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A Technique for Maintaining Acarine Predator-Prey Populations

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Experiments with the growth-forms of acarine predator and prey populations require a constant supply of both species. This note describes a technique used for maintaining large numbers of *Tyrophagus castellanii* (Hirst) and its predator *Melichares dentriticus* (Berl.) and of *Acarus siro* L. and its predator *Cheyletus eruditus* (Schrank).

Prey populations are propagated from individual female adults in a microcell similar to the type commonly used (Rivard, 1958). The cell (Fig. 1) consists

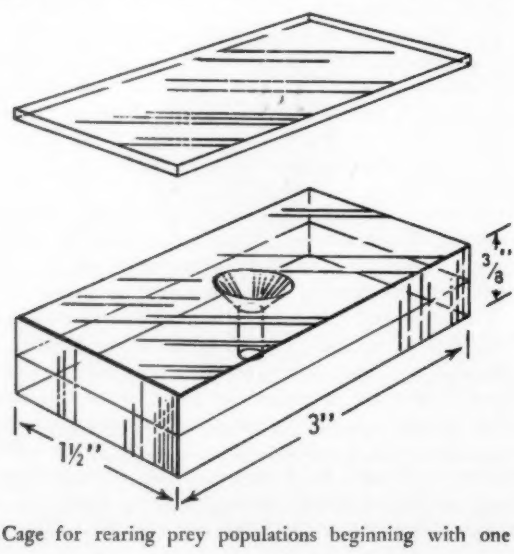

Fig. 1. Cage for rearing prey populations beginning with one female.

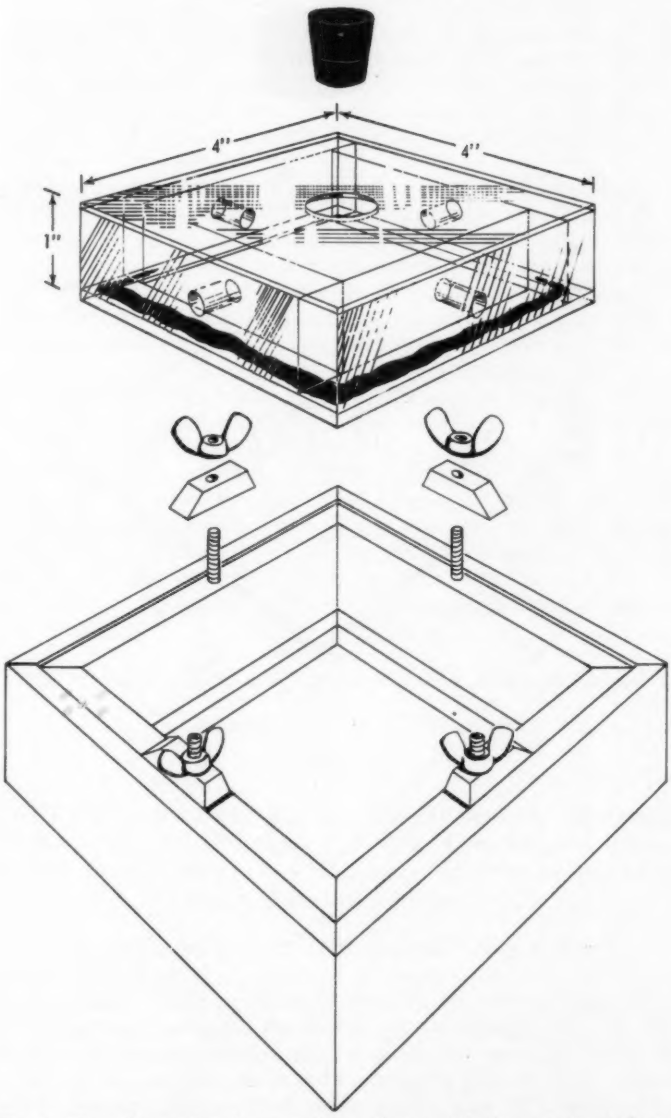

Fig. 2. Cage for rearing large numbers of prey infesting stored products.

of a conical hole drilled in a piece of acrylic plastic three-sixteenths of an inch thick. The bottom of this hole is covered with bolting cloth and is superimposed on a hole of the same diameter in a second piece of plastic that is cemented to the first with ethylene chloride. After the cell is filled with food the top is covered with a microscope slide held in place with small rubber bands. When up to 400 prey are required they can be reared in the cage shown in Fig. 2. The top of the cage is fastened to the four sides, each with an aeration hole covered with bolting cloth. The bottom of the cage is a piece of glass which is

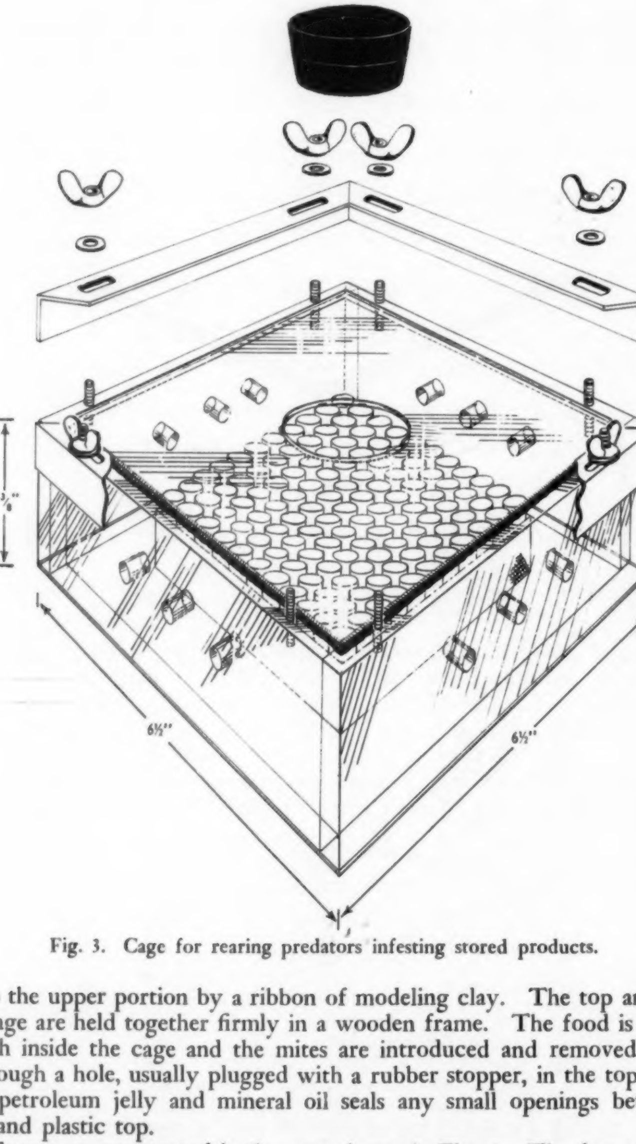

Fig. 3. Cage for rearing predators infesting stored products.

sealed to the upper portion by a ribbon of modeling clay. The top and bottom of the cage are held together firmly in a wooden frame. The food is in a small petri dish inside the cage and the mites are introduced and removed from the cage through a hole, usually plugged with a rubber stopper, in the top. A mixture of petroleum jelly and mineral oil seals any small openings between the stopper and plastic top.

Predators are propagated in the cage shown in Fig. 3. The four sides (one-half inch thick), each with three holes covered with bolting cloth, are cemented to the bottom with ethylene chloride. The top of the cage is sealed in a rebate, cut in the sides of the cage, by a ribbon of modeling clay. The top is held firmly in place by strips of angle-aluminum fastened by wing-nuts on bolts set in the side of the cage. The food is in 144 glass vials, 9 by 30 mm., that are in a metal tray inside the cage. Prey and predators are introduced and removed through an opening, usually plugged with a rubber stopper, in the top of the cage.

The bolting cloth covering the aeration holes in all cages has 238 meshes to the linear inch. Several layers of cloth can be cemented together by a solution of the plastic dissolved in ethylene chloride and the meshes cleared by compressed air before the plastic sets. If small mites, such as the larvae of *T. castellanii*, are reared it is necessary to tightly plug the openings with cotton batten.

A number of foods, such as wheat flakes or baby-food cereal, may be used for the propagation of the prey. The flakes are sifted to the desired size, soaked in a solution of ether and mold inhibitor (1 gm. Shirlan per 100 cc. ether; 1 part of solution to 2 parts of food), and supplemented with 0.25 per cent brewer's yeast for *T. castellanii* or 2 per cent raw wheat germ (80 mesh in size) (0.6 gms. Shirlan per 100 cc. ether; one part solution to two parts wheat germ) for *A. siro*.

If the predators are reared in the cage shown in Fig. 2 the prey are consumed in about three weeks; the short period of use necessitates the propagation of a large number of populations. Use of the cage shown in Fig. 3 permits a choice of size of food so that the smaller prey species can be given physical protection from the larger predacious species and a portion of the food supply can be renewed when necessary. Populations of *T. castellanii* and *M. dentriticus* were propagated at 76° F. and 80 per cent R.H. without a change of food for more than one year on wheat flakes that will pass through a screen of 16 meshes to the inch but not through a 20-mesh screen. Similarly, populations of *A. siro* and *C. eridutus* have been maintained for over one year on flakes of 20-30 meshes in size. For reasons of sanitation, however, populations are usually kept for only four to five months.

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(Received December 9, 1959)

Studies of Predators of the Balsam Woolly Aphid, *Adelges piceae* (Ratz.) (Homoptera: Adelgidae)[1,2] VII. *Laricobius rubidus* Lec. (Coleoptera: Derodontidae), a Predator of *Pineus strobi* (Htg.) (Homoptera: Adelgidae)

By R. C. Clark[3] and N. R. Brown[4]

Although *Laricobius rubidus* LeConte (1861, 1866) is not a common predator of the balsam woolly aphid, *Adelges piceae* (Ratz.), this paper is included in the series because of the close taxonomic similarities of *L. rubidus* in all stages to the recently introduced *L. erichsonii* Rosenh. In the past there has been confusion in the literature because the majority of records of *rubidus* have been erroneously attributed to *erichsonii*. These records have been discussed in detail in a paper on *L. erichsonii*, a species which has been introduced into North America as part of a biological control program against *A. piceae* (Clark and Brown, 1958).

L. rubidus has been known to feed only on *Pineus strobi* (Htg.), a common adelgid infesting the trunk and larger branches of eastern white pine, *Pinus strobus* L. Prior to the introduction of the European *L. erichsonii*, derodontids had not

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been recorded as predators of *A. piceae* in North America. Following the introduction of *L. erichsonii*, collections of derodontids from the two adelgid hosts have been made regularly in central New Brunswick. *L. erichsonii* has been recorded from *P. strobi* infestations on only three occasions — one adult male on each of April 15, April 25, and May 20, 1958. On May 26, 1958 two male *L. rubidus* were collected from the trunk of a balsam fir infested with *A. piceae*. Since the females of the two species cannot be separated with certainty, it is still not known whether or not either predator attacks both prey species in Canada. Franz (1958) lists the following adelgids which act as prey of *L. erichsonii* in different parts of Europe: *Adelges piceae* on fir (*Abies* spp.); *A. nüsslini* C.B. on fir; *Pineus pineoides* Cholodk. on spruce (*Picea* spp.); *P. strobi* on white pine; *A. cooleyi* (Gill.) on Douglas fir, *Pseudotsuga menziesii* (Mirb.) Franco. Adults have been found on all these hosts and larvae on all but *A. cooleyi*. The preferred host in Europe has been found in nearly all cases to be *A. piceae* although Franz states also that *L. erichsonii* is not particularly well adapted to this host as there is a lack of synchronization of generations and times of activity.

Distribution records of *rubidus* indicate that the species probably extends over the range of eastern white pine. W. J. Brown (1944) states that it has been collected in Michigan, Ottawa, Ont., and Quebec as well as from several intermediate localities. Mr. Brown has checked the identification of 29 specimens borrowed from the collections of the United States National Museum, Cornell University, and the University of Massachusetts. These were collected between 1898 and 1943 from the following locations: Rock Creek, D.C.; four locations in New York State; four locations in Massachusetts; Detroit, Michigan; Toronto and one other unspecified location in Ontario.

Life History and Habits

Adults of *L. rubidus* that had overwintered first appeared in early spring in central New Brunswick about the time the snow cover disappeared from around the bases of white pine trees. The beetles were active from about March 24 to June 1, with maximum adult activity from April 14 to May 12. In 1958, 164 adults were observed from five places close to Fredericton. Of 98 adults sent to Ottawa for determination by W. J. Brown of the Entomology Research Institute, Ottawa, three were male *L. erichsonii*, 46 were male *L. rubidus*, and 49 were females (species undetermined). On the assumption that most of the females were *L. rubidus*, the sex ratio was approximately 1:1. Copulating adults were found from March 31 to May 5. In 1959 a total of 88 adults were collected at Fredericton from March 31 to April 21.

These adults were found on infested pine trees of all sizes, usually on smooth areas of the trunk, near the base of larger branches and particularly just below branch whorls, where *P. strobi* tends to occur in larger numbers. Occasionally adults were found wandering about on uninfested areas of the trunk and also far out on the branches, around the buds and needles, where the prey, though often present, is found in smaller numbers. Both *L. rubidus* and *L. erichsonii* have a strong tendency to drop from the trees when disturbed or when rapid movements are made near the trunks of the trees.

Feeding by adult beetles was not observed. In the spring, when the beetles are active from about April 25 to May 20, intermediate stages and adults of *P. strobi* are present; the latter begin to lay eggs by mid May.

The oviposition period of *L. rubidus* extends from mid-April to approximately the end of May; eclosion occurs within a week. Eggs are laid singly, deep within the "wool" secretion of the prey, sometimes within the egg mass

itself. Laboratory observation has shown that the process of depositing a single egg takes approximately 15 minutes. The egg, which measures 0.40 mm. by 0.29 mm., is creamy-yellow in colour, oval in shape, and has a smooth, shiny chorion. The freshly deposited egg is apparently covered with a thin mucilaginous secretion to which the adelgid "wool" readily adheres, thus fixing the egg securely within the "wool" mass and affording protection until eclosion. The eggs, being of a different colour, are easily distinguishable from those of the prey.

The four larval instars are present in the field for a period of about two months. First-instar larvae were observed as early as April 20, and last-instar larvae as late as June 15. Collection of a few second- and third-instar larvae on August 3, 1948, suggests that a partial second generation occurs in New Brunswick and that farther south a second generation may occur regularly.

As pupae have not been found on the trunks of infested trees, they are probably formed in the ground, as in *L. erichsonii.* The pupal period apparently begins between the middle and the end of June. It is not known whether or not the beetles emerge from the ground later in the season, as *L. erichsonii* does, and then return to the ground for hibernation. However, this habit is suggested by the presence in the Cornell University collection of one specimen from Toronto, Ontario, labelled December. At Fredericton, adults have not been observed after late June.

On December 3, 1958, soil was removed from around the bases of two infested white pine trees (1 in. and 8 in. d.b.h.) and from one tree (6 in. d.b.h.) on July 31, 1959 to a distance of about two feet from the trunks and to a depth of eight inches. No hibernating *L. rubidus* adults were found in the soil. It is in a similar position around balsam fir trees that *L. erichsonii* pupates and hibernates.

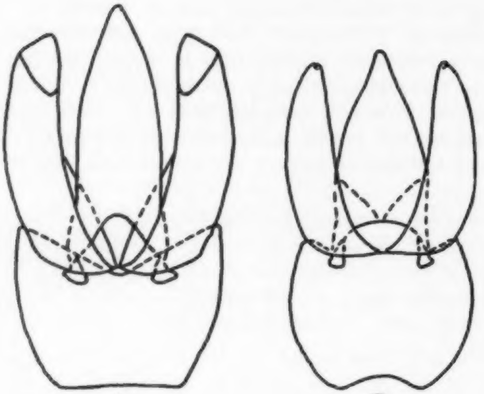
The life cycle is fairly well synchronized with that of *P. strobi.* The larvae feed on intermediate stages, adults, and eggs, all of which are available throughout the larval period.

Control Value

Infestations of *P. strobi* continue for a number of years at a moderate to heavy intensity without causing noticeable damage. Two predators are common in central New Brunswick on infested pine: *Neoleucopis pinicola* Mall. (Diptera: Chamaemyiidae) (Clark and Brown, 1957), and *L. rubidus.* Even in the presence of these two, the adelgid maintains high populations year after year. The predators probably limit the degree of infestation but exist in a balance with the prey at a rather high level of abundance that does not, however, cause damage to the pine.

Differentiation from *L. erichsonii*

Four species of *Laricobius* are known in North America. Of these, *L. laticollis* Fall (1916) and *L. nigrinus* Fender (1945) are known only from the west coast. *L. erichsonii* has been successfully introduced as a predator of *A. piceae* in eastern Canada and U.S.A. since 1951. The evidence seems conclusive that the species was not previously present in North America (Clark and Brown, 1958) and records of *L. erichsonii* prior to 1951 are considered erroneous. We have been able to obtain some of the specimens concerned and all were determined by W. J. Brown as *L. rubidus.* Brown (1944) distinguishes them as follows: "In *rubidus* the lateral lobes of the aedeagus are obliquely truncate; in *erichsonii* the aedeagus is relatively smaller and its median lobe is wider than in either of the American species" (Figs. 1, 2).



Figs. 1, 2. Aedeagi of species of *Laricobius* Rosenh. 1, *L. rubidus* Lec.; 2, *L. erichsonii* Rosenh. (From Brown, 1944).

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